We put more in, to help you get more out.

Choice of 40 configurations for biliary, nephrostomy, and multipurpose needs

Easy-to-use hub with audible, visual, and tactile locking feedback

Hydrophilic coating extends beyond the tip

We didn’t just expand our line of percutaneous drainage products to give you more options in more procedures—we also engineered them with unique features designed to maximize lubricity, echogenicity, and ease of use.

IMPORTANT RISK INFORMATION

Mini Stick ENVI
INDICATION FOR USE: The Mini Stick ENVI Non-Vascular Introducer Kit is utilized to facilitate the introduction and placement of a 0.035 in (0.89 mm) or 0.039 in (0.97 mm) diameter guidewire for non-vascular procedures.
CONTRAINDICATIONS: None known.

Exodus Drainage Catheters
INDICATION FOR USE: Exodus Array Multipurpose Drainage Catheters are intended for percutaneous drainage of fluid or air in the chest, abdomen, and pelvis, e.g., abscesses, cysts, pneumothorax, biliary, nephrostomy, urinary, pleural, empyemas, lung abscesses, and mediastinal collections.
Exodus Nuance Nephrostomy Drainage Catheters are intended for percutaneous drainage of fluid collections on the urinary system.
Exodus Believe Biliary Drainage Catheters are intended for percutaneous drainage of the biliary tree.
CONTRAINDICATIONS: Bleeding diathesis and anticoagulant use.

INTENDED USE/INDICATIONS FOR USE: Nitinol Guidewire with Tungsten Tip (FDA Approved)
The Nitinol Guidewire with Tungsten Tip is used to facilitate the introduction and placement of a 0.035 in (0.89 mm) or 0.038 in (0.97 mm) diameter guidewire for non-vascular procedures.
CONTRAINDICATIONS: None known.

INTENDED USE/INDICATIONS FOR USE: Nitinol Guidewire with Tungsten Tip (CE Marked)
Vascular: The Nitinol Guidewire with Tungsten Tip is used for percutaneous entry of peripheral vessels using the Seldinger Technique. This device is not indicated for use in the coronary or cerebral vasculature.
Non-Vascular: The Nitinol Guidewire with Tungsten Tip is used to facilitate the introduction and placement of a 0.035 in (0.89 mm) or 0.038 in (0.97 mm) diameter guidewire for non-vascular procedures.
CONTRAINDICATIONS: None known.
Refer to Directions for Use provided with the product for complete instructions, warnings, and precautions/cautions.
CAUTION: Federal Law (USA) restricts this device to sale by or on the order of a physician.
We put more in, to help you get more out.

- **Radiopaque sheath tip**
- **Dimpling for enhanced echogenicity**
- **Hydrophilic coating for less friction on insertion**
- **Easy-to-use hub with audible, visual, and tactile locking feedback**
- **Choice of 40 configurations for biliary, nephrostomy, and multipurpose needs**

**IMPORTANT RISK INFORMATION**

**Mini Stick ENVI**

**INDICATION FOR USE:** The Mini Stick ENVI Non-Vascular Introducer Kit is utilized to facilitate the introduction and placement of a 0.035 in (0.89 mm) or 0.039 in (0.97 mm) diameter guidewire for non-vascular procedures.

**CONTRAINDICATIONS:** None known.

---

**Exodus Drainage Catheters**

**INDICATION FOR USE:** Exodus Array Multipurpose Drainage Catheters are intended for percutaneous drainage of fluid or air in the chest, abdomen, and pelvis, e.g., abscesses, cysts, pneumothoraces, biliary, nephrostomy, urinary, pleural, empyemas, lung abscesses, and mediastinal collections.

**Exodus Nuance Nephrostomy Drainage Catheters** are intended for percutaneous drainage of fluid collections on the urinary system.

**Exodus Believe Biliary Drainage Catheters** are intended for percutaneous drainage of the biliary tree.

**CONTRAINDICATIONS:** Bleeding diathesis and anticoagulant use.

---

**INTENDED USE/INDICATIONS FOR USE:** Nitinol Guidewire with Tungsten Tip (FDA Approved)

The Nitinol Guidewire with Tungsten Tip is used to facilitate the introduction and placement of a 0.035 in (0.089 mm) or 0.038 in (0.97 mm) diameter guidewire for non-vascular procedures.

**CONTRAINDICATIONS:** None known.

**INTENDED USE/INDICATIONS FOR USE:** Nitinol Guidewire with Tungsten Tip (CE Marked)

- **Vascular:** The Nitinol Guidewire with Tungsten Tip is used for percutaneous entry of peripheral vessels using the Seldinger Technique. This device is not indicated for use in the coronary or cerebral vasculature.
- **Non-Vascular:** The Nitinol Guidewire with Tungsten Tip is used to facilitate the introduction and placement of a 0.035 in (0.089 mm) or 0.038 in (0.97 mm) diameter guidewire for non-vascular procedures.

**CONTRAINDICATIONS:** None known.

Refer to Directions for Use provided with the product for complete instructions, warnings, and precautions/cautions.

**CAUTION:** Federal Law (USA) restricts this device to sale by or on the order of a physician.

---

To learn more about the tip-to-hub benefits of Exodus drainage catheters and the new Mini Stick ENVI non-vascular introducer kit, visit us at SIR booth 309 or contact Customer Service at 1-800-772-6446.
The Corporate Ambassador Program (CAP) is a high-impact, coordinated recognition program that helps advance the mission of the society and its foundation. Join us in thanking our CAP partners, who have chosen to invest in IR today and in the future.

To become a 2018 CAP participant, please contact Erica Holland at (703) 460-5568 or eholland@sirweb.org.

**LEADER LEVEL**
- Boston Scientific Corporation, Inc.
- BTG International, Inc.
- Medtronic

**CHAMPION LEVEL**
- Penumbra, Inc.
- Sirtex Medical, Inc.

**ADVOCATE LEVEL**
- Cook Medical
- Cordis, a Cardinal Health Company
- CR Bard
- Guerbet, LLC
- Siemens Healthineers
- Stryker IVS

**FRIEND LEVEL**
- Argon Medical Devices
- Change Healthcare
- Endocare, Inc.

*As of Dec. 31, 2017.*
Welcome to the SIR 2018 Annual Scientific Meeting

Dear Colleague,

Welcome to the JVIR special supplement on the SIR 2018 Annual Scientific Meeting, the world’s largest and most comprehensive educational meeting for the IR community and associated professionals. This year attendees will see expansion in both topic and speaker diversity as we bring together experiences and perspectives from IR experts around the world to improve the overall learning experience.

This year’s Annual Meeting Committee has reduced the number of talks given by individuals, creating more opportunities for a wider variety of interventional radiologists to share their insights and findings. This diversification of speakers allows us to communicate the remarkable power of the specialty to all attendees, from a wide range of unique perspectives.

The broad range of educational areas covered in this year’s scientific program reflects the large volume of quality submissions. Authors from more than 22 countries submitted abstracts for SIR 2018, making our meeting a true global showcase of IR innovation and excellence.

These scientific sessions, the heart of the Annual Scientific Meeting, are where you will hear directly from the researchers about the abstracts contained within this supplement: the clinical trials, technical innovations and foundational science that enhance practice and propel the specialty. Indeed, many of the procedures that we regularly perform were introduced during Annual Scientific Meeting scientific sessions.

SIR has continued last year’s popular electronic posters (e-posters) exhibit. To make room for the higher number of scientific abstracts, SIR has pulled all educational abstracts into a separate document, available for viewing on jvir.org.

We look forward to seeing you at the scientific sessions and hope that you leave the meeting with a preview of tomorrow’s practice of interventional radiology.

Brian Funaki, MD, FSIR
Chair, 2018 Annual Meeting Program

Constantino Peña, MD, FSIR
Chair, 2018 Scientific Program
Your patients are looking for safe and effective treatment of their venous disease, but if you’re only treating above the knee, you could leave them with a persistent problem. Residual symptoms and the need for reintervention are reported in nearly 50% of patients if the refluxing GSV below the knee is left untreated.¹

The VenaCure 1470 nm laser and NeverTouch fiber have been shown to safely and effectively ablate the GSV below the knee, with minimal complications (postoperative paresthesia occurred in 4% of patients, and resolved within 4 weeks).¹

Learn more about the procedure that has been performed more than 1 million times and help your patients get relief from their venous disease symptoms by treating below the knee.

Table of Contents
Volume 29
Number 4S
April 2018

vi  SIR and SIR Foundation organizational structure
vii  JVIR editorial board
viii  2018 honorees
xii  SIR Foundation research awards
S1  Scientific abstracts and reviewers
S3  Abstracts chosen by the Annual Scientific Meeting Committee
S5  Scientific oral presentations
S176  Scientific e–posters
S295  Author index

Educational exhibit e–posters*
Traditional educational posters*

Acknowledgment
Publication of this supplement was made possible by a grant from AngioDynamics.

Disclaimer
SIR assumes no legal liability or responsibility for the completeness, accuracy and correctness of the information presented in the abstracts. Abstracts are published in the Annual Meeting Supplement to the Journal of Vascular and Interventional Radiology as submitted by the authors, except for minor stylistic adjustments to ensure consistency of format and adherence to Supplement style.

Dosages, indications and methods of use for products that are referred to in the supplement by the authors may reflect their clinical experience or may be derived from the professional literature or other clinical sources. Because of the differences between in vitro and in vivo systems and between laboratory animal models and clinical data in humans, in vitro and animal data may not necessarily correlate with clinical results.

Content current as of Jan. 3, 2018.

*Available online at: www.jvir.org/content/sir_supplements.
SIR and SIR Foundation organizational structure

2018 Annual Scientific Meeting Committee
Brian Funaki, MD, FSIR, Chair, SIR 2018
Daniel Sze, MD, FSIR, Chair, Workshop Program
Constantine Peña, MD, FSIR, Chair, Scientific Program
Robert Lewandowski, MD, FSIR, Chair, SIR 2017
Constantinos T. Sofocleous, MD, PhD, FSIR, International Division Chair

2017–2018 SIR Executive Council
Suresh Vedantham, MD, FSIR, President
M. Victoria Marx, MD, FSIR, President-elect
Laura Findeiss, MD, FSIR, Secretary
Matthew S. Johnson, MD, FSIR, Treasurer
Charles E. Ray Jr., MD, PhD, FSIR, Immediate Past President
Filip Banovac, MD, FSIR, SIR Foundation Chair
Brian Funaki, MD, FSIR, Annual Scientific Meeting Division Chair
Raymond W. Liu, MD, FSIR, Health Policy and Economics Division Chair
Parag Patel, MD, FSIR, Graduate Medical Education Division Chair
Daniel B. Brown, MD, FSIR, Postgraduate Medical Education Division Chair
Sanjeeva Kalva, MD, FSIR, Member Services Division Chair
Alda Tam, MD, FSIR, Standards Division Chair
Brian F. Stainken, MD, FSIR, International Division Chair
Sanjay Misra, MD, FSIR, Councilor-at-Large
Kevin Dickey, MD, FSIR, Councilor-at-Large
Michael D. Bake, MD, FSIR, Councilor-at-Large
Ziv J Haskal, MD, FSIR, JVIR Editor
Meredith J. Englander, MD, FSIR, AMA Delegate, ex-officio
Gerald A. Niedzwiecki, MD, FSIR, Ad-hoc Councilor, Private Practice
Robert Lookstein, MD, FSIR, Ad-hoc Councilor, Alternative Payment Models
Susan E. Sedory, MA, CAE, Executive Director, ex-officio

2017–2018 SIR Foundation Board of Directors
Filip Banovac, MD, FSIR, Chair
Jeremy C. Durack, MD, MS, FSIR, Vice Chair
Stephen T. Kee, MD, MMM, FSIR, Immediate Past Chair
Matthew S. Johnson, MD, FSIR, SIR and SIR Foundation Treasurer
Jeremy D. Collins, MD, FSIR, Quality and Outcomes Division Chair
R. Torrance Andrews, MD, FSIR, Development Division Chair
Erik N.K. Cressman, MD, PhD, FSIR, Research Grants and Education Division Chair
Sarah B. White, MD, MS, FSIR, Clinical Research and Registries Division Chair
Suresh Vedantham, MD, FSIR, SIR President
M. Victoria Marx, MD, FSIR, SIR President-elect
Raymond W. Liu, MD, FSIR, SIR Health Policy and Economics Division Chair
Daniel B. Brown, MD, FSIR, SIR Postgraduate Medical Education Division Chair

Ziv J Haskal, MD, FSIR, JVIR Editor
Carolyn Strain, MA, MS, SIR Foundation Executive Director
Susan E. Sedory, MA, CAE, SIR Executive Director

SIR Staff
Susan E. Sedory, MA, CAE, Executive Director
Erica Holland, Assistant Executive Director, Meetings, Education, Corporate Relations and Member Services
Carolyn Strain, MA, MS, Executive Director, SIR Foundation and Assistant Executive Director for Research
Ellen S. Acconcia, Director, Marketing
Molly S. Barlow, CAE, CMP, Director, Meeting Operations
Craig Blouir, MCSA, PMP, Director, Information Technology
Elise Castelli, Director, Communications and Public Relations
Elena Coler, Manager, Journal
Caitlin Couture, CAE, Director, Governance and Engagement
Tori Cox, Program Manager, Volunteer Engagement
Susie Evenden, Manager, Exhibits and Corporate Relations
Becca Ginns, Senior Manager, Development
Joy Gormal, Director, Membership and Graduate Medical Affairs
Jennifer Goubeaux, Program Manager, Graduate Medical Affairs
Brian Haefs, Director, Publications
Zuhair Haidari, MPH, CPHQ, Director, Quality Performance and Improvement
Elizabeth Himes, Research Assistant
Bertina Hurtt, Receptionist
Douglas Huynh, JD, Director, Government and Policy Affairs
Debbie Katsarelis, Senior Manager, Guidelines and Intersociety Affairs
Tayler Kenney, Coordinator, Meetings
Ji-Youn Lee, Staff Accountant
Christian Lopez, Corporate Relations Associate
Kate Martin, Coordinator, Communications
Eleanore Hernandez Moye, MS, CCRP, PMP, Director, Research and Grants
Sara Myers, MPH, Manager, Grants and Research
Elizabeth Nicholson, Manager, Education Offerings
Jeff Nielsen, Senior Director of Finance for SIR and SIR Foundation
Molly O’Neill, Coordinator, Professional Education and Certification
Debbie Ramsburg, Coordinator, Health Policy and Quality
Jennifer Rowley, Director, Education Products and Services
Cheryl Sadowski, Senior Director, Communications, Publications and Marketing
Chandra Senroy, Manager, Marketing
Shivane Sharma, Human Resource Specialist
Shaun Singletary, Member Services Associate
Suzanne Walshaw, Senior Accountant
Robert White, Director, Reimbursement and Hospital Affairs
Elizabeth Willson, MHA, Senior Director, Health Policy and Quality
Terianne Zeifman, Director, Development
# Editorial Board

## Journal of Vascular and Interventional Radiology

### Ziv J Haskal, MD, FSIR

*Editor-in-Chief*

University of Virginia School of Medicine, Charlottesville, Va

### Boris Nikolic, MD, MBA

*Deputy Editor*

Stratton Medical Center, Albany, NY

### EDITORS EMERITI

<table>
<thead>
<tr>
<th>Name</th>
<th>Years</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gary J. Becker, MD</td>
<td>1990–1995</td>
<td>Tucson, Ariz</td>
</tr>
<tr>
<td>Daniel Picus, MD</td>
<td>1995–2000</td>
<td>St. Louis, Mo</td>
</tr>
<tr>
<td>Karim Valji, MD</td>
<td>2001–2005</td>
<td>Seattle, Wash</td>
</tr>
<tr>
<td>Albert A. Nemcek, Jr, MD</td>
<td>2006–2010</td>
<td>Chicago, Ill</td>
</tr>
</tbody>
</table>

### ASSOCIATE EDITORS

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nadine Abi-Jaoudeh, MD</td>
<td>Irvine, Calif</td>
</tr>
<tr>
<td>Yasuaki Arai, MD</td>
<td>Tokyo, Japan</td>
</tr>
<tr>
<td>Tiago Bilhim, PhD, MD</td>
<td>Lisbon, Portugal</td>
</tr>
<tr>
<td>Thomas A. Farrell, MD</td>
<td>Wilmette, Ill</td>
</tr>
<tr>
<td>Brian Funaki, MD</td>
<td>Chicago, Ill</td>
</tr>
<tr>
<td>Ron C. Gaba, MD</td>
<td>Chicago, Ill</td>
</tr>
<tr>
<td>Joseph J. Gemmete, MD</td>
<td>Ann Arbor, Mich</td>
</tr>
<tr>
<td>Yoh-Cheol Kim, MD</td>
<td>Seoul, Korea</td>
</tr>
<tr>
<td>Maureen P. Kohi, MD</td>
<td>San Francisco, Calif</td>
</tr>
<tr>
<td>Elliott B. Levy, MD</td>
<td>Bethesda, Md</td>
</tr>
<tr>
<td>Mehran Midia, MD</td>
<td>Hamilton, Ontario, Canada</td>
</tr>
<tr>
<td>Sanjiv Sharma, MD</td>
<td>Delhi, India</td>
</tr>
<tr>
<td>James E. Silberzweig, MD</td>
<td>New York, NY</td>
</tr>
<tr>
<td>Gary P. Siskin, MD</td>
<td>Albany, NY</td>
</tr>
<tr>
<td>Miyuki Sone, MD</td>
<td>Chuo-ku, Japan</td>
</tr>
</tbody>
</table>

### FEATURES EDITORS

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osman Ahmed, MD</td>
<td>Chicago, Ill</td>
</tr>
<tr>
<td>Joe Ensor, PhD</td>
<td>Houston, Tex</td>
</tr>
<tr>
<td>Kyle Aaron Jones, PhD</td>
<td>Houston, Tex</td>
</tr>
<tr>
<td>Frederick S. Keller, MD</td>
<td>Portland, Or</td>
</tr>
<tr>
<td>Nishita Kothary, MD</td>
<td>Stanford, Calif</td>
</tr>
<tr>
<td>Alan H. Matsumoto, MD</td>
<td>Charlottesville, Va</td>
</tr>
</tbody>
</table>

### EDITORIAL OFFICE

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elena Coler</td>
<td>SIR Journal Manager</td>
</tr>
<tr>
<td>Lindsey Huckabee and Annastasia Pratt</td>
<td>Submissions Management</td>
</tr>
</tbody>
</table>
34th Annual Dr. Charles T. Dotter Lecture

This award honors one of the founding fathers of interventional radiology, Dr. Charles T. Dotter. Selection by the SIR president is based on extraordinary contributions to the field, dedicated service to the Society and distinguished career achievements in interventional radiology. Honorees deliver the lecture at SIR’s Annual Scientific Meeting.

SIR congratulates the 2018 Dr. Charles T. Dotter Lecturer:

Timothy P. Murphy, MD, FSIR

34th Annual Charles T. Dotter Lecture will be held on Sunday, March 18, at 10:30 a.m.
West Exhibit Hall B, Los Angeles Convention Center
2018 Gold Medalists

The Society of Interventional Radiology's Gold Medal is awarded to a member who has helped ensure the future of interventional radiology by advancing the quality of medicine and patient care. The SIR Gold Medal, the society's highest honor, is bestowed for distinguished and extraordinary service to SIR or to the discipline of interventional radiology.

The Gold Medal presentation will take place on Sunday, March 18, at 10:30 a.m. in the West Exhibit Hall B, Los Angeles Convention Center.

SIR congratulates the 2018 Gold Medalists:

John A. Kaufman, MD, MS, FSIR
Renate L. Soulen, MD, FSIR
Karim Valji, MD, FSIR

SIR Foundation honorees

Leaders in Innovation Award

The Leaders in Innovation Award recognizes and promotes innovation within interventional radiology, continuing IR’s historical innovative development that has revolutionized medicine over the last 40 years. The Award acknowledges those individuals who have conceptualized and implemented an idea that has had an advantageous impact on the practice of interventional radiology. The innovation can be a device, technique, approach, clinical practice model, or anything having a significant improvement upon the quality of patient care or economics of interventional practice.

This award will be presented at 10:30 a.m. on Monday, March 19.

SIR and SIR Foundation congratulate the 2018 Leaders in Innovation Award winner:

Thomas McNamara, MD, FSIR
The Dr. Gary J. Becker Young Investigator Award promotes excellence in academic research for members early in their careers. This award honors the founding editor of the Journal of Vascular and Interventional Radiology (JVIR) by recognizing the importance of the young investigator in developing the interventional solutions for the future.

In 1990, SIR Foundation established the Dr. Gary J. Becker Young Investigator Award as a way to recognize promising young practitioners of interventional medicine early in their careers and encourage their pursuit of academic careers. Each year an author of the most outstanding clinical science research paper submitted receives this distinguished award.

This award will be presented at 10:30 a.m. on Monday, March 19.

SIR and SIR Foundation congratulate the 2018 Dr. Gary J. Becker Young Investigator Award winner:

**Ammar Sarwar, MD**

**Frederick S. Keller, MD, Philanthropy Award**

This award honors an individual who, through exceptional generosity and/or through inspiring others to give, demonstrates outstanding commitment to SIR Foundation. Constantin Cope, MD, FSIR, is being honored posthumously with this award, which will be presented to Dr. Cope’s family during SIR Foundation’s 8th annual Gala taking place on Sunday, March 18.

**Constantin Cope, MD, FSIR**
Journal of Vascular and Interventional Radiology (JVIR) honorees

JVIR Awards for Outstanding Research

The JVIR Awards for Outstanding Research are made possible through SIR Foundation. The Journal of Vascular and Interventional Radiology (JVIR) grants awards for exceptional research published in the journal in two categories: clinical research and laboratory investigation. The winning manuscripts are selected after a rigorous review of all JVIR articles published in the preceding year, voted on by the present editors and decided on by the editor-in-chief. The chosen articles represent research that may substantially impact the IR community at present or in the future. These awards will be presented during the SIR 2018 Film Panel and JVIR Awards plenary session, on Tuesday, March 20, at 10:30 a.m.

JVIR Outstanding Reviewer Awards

JVIR honors its outstanding reviewers for their superior editorial service in 2017. These individuals distinguished themselves through the degree of excellence and insight of their reviews, efficiency by which they work and finally the impressive quantity of reviews they performed on behalf of JVIR. The journal’s success depends on the dedication and expertise of its reviewers to critically and impartially assess submitted manuscripts for their originality, scientific and educational value and contribution to IR literature. The JVIR Outstanding Reviewer Awards will be presented at the annual JVIR Reviewer Reception, by invitation only, in Room Diamond 6, JW Marriott, on Saturday, March 17, from 5:30–6:30 p.m. Watch sirmeeting.org for details.
SIR Foundation is a scientific foundation dedicated to fostering research in interventional radiology for the purposes of advancing scientific knowledge, increasing the number of skilled investigators and developing innovative therapies that lead to improved patient care and quality of life. The foundation is committed to developing and enhancing innovative, minimally invasive, image-guided therapies from inception to mature clinical application and to conducting educational programs in the service of its mission.

Each year SIR Foundation proudly supports award programs that recognize outstanding achievements in research and innovation. The 2018 research awards will be presented at 10:30 a.m. on Monday, March 19.

**Dr. Constantin Cope Medical Student Research Award**

- Obstructive cholangiocarcinoma: hilar location as an indication for initial percutaneous management (Oral presentation Abstract #160 to be presented Monday, March 19, at 3 p.m.)—Ross Warren Bittman, Emory University School of Medicine
- Relationship of hospital volume on length of stay in patients diagnosed with pulmonary embolism (Oral presentation Abstract #222 to be presented Tuesday, March 20, at 3:09 p.m.)—Mark Finkelstein, Icahn School of Medicine at Mount Sinai Hospital
- Analysis of in vivo tumor growth kinetics in a diethylnitrosamine-induced, transarterial embolization-treated rat model of HCC (Oral presentation Abstract #320 to be presented Wednesday, March 21, at 4:12 p.m.)—Ryan McEnrue Kiefer, University of Pennsylvania
- In vitro feasibility study of magnetic resonance navigation in realistic physiological settings (Oral presentation Abstract #314 to be presented Wednesday, March 21, at 3:18 p.m.)—François Michaud, Université de Montréal
- Do liver function scoring systems predict outcomes after portal vein embolization in non-HCC liver cancer? (Oral presentation Abstract #363 to be presented Wednesday, March 21, at 3:10 p.m.)—Avik Som, Washington University in St. Louis School of Medicine
- Rapid coaxial probe electrochemical (CoPE) ablation device iteration using computer aided design (CAD) and 3D printing (Oral presentation Abstract #342 to be presented Wednesday, March 21, at 3 p.m.)—Elliot Joshua Stein, Perelman School of Medicine at the University of Pennsylvania

**Radiology Resident/Fellow Research Award**

- Epigenetic alterations enable HCC cell survival under metabolic stress (Oral presentation Abstract #348 to be presented Wednesday, March 21, at 4 p.m.)—Jamaal Benjamin, MD, PhD, Hospital of the University of Pennsylvania, University of Pennsylvania
- Long-term survival outcomes of early stage HCC undergoing Y90 radiation segmentectomy (Oral presentation Abstract #89 to be presented Sunday, March 18, at 4:12 p.m.)—Ahmed Gabr, MD, Northwestern University
- Lymphopenia selects poor DEB-TACE response in transplant waitlist patients: Prospective, single-center, observational study (Oral presentation Abstract #35 to be presented Sunday, March 18, at 3:18 p.m.)—Tyler Sandow, MD, Ochsner Health System
2018 Scientific Abstracts and Reviewers

Scientific Abstract Reviewers
The Annual Scientific Meeting Committee is indebted to the 2018 scientific abstract reviewers for their valuable contribution to the meeting.

Scientific Program Chair
Constantino S. Pena, MD, FSIR
Nadine Abi-Jaoudeh, MD, FSIR
Sun-Ho Ahn, MD, FSIR
Kamran Ahrar, MD, MBA, FSIR, FACR
Ragheed Al-Dulaimi, MD, MPH
Ramsey A. Al-Hakim, MD
Sabina Amin, MD
R. Torrance Andrews, MD, FSIR
Mohammad Arabi
Bulent Arslan, MD
Rony Avritscher, MD
Ezana M. Azene, MD, PhD
Sandeep Bagla, MD
Curtis W. Bakal, MD, MPH, FSIR
David S. Ball, DO, FSIR
Richard Baumi, MD, FSIR
Robert E. Beasley, MD, FSIR
Avi Beck, MD
Nikhil Bhagat
Shivank S. Bhatia, MD
Lynn Brody, MD, FSIR
Olga R. Brook, MD
Lawrence C. Calabrese, MD
Juan Camilo Camacho, MD
Lauren Chan, MD
Cherng Chao
Jeffrey Forris Beecham Chick, MD, MPH
Howard B. Chrisman, MD, MBA, FSIR
Kyle J. Cooper, MD
Jeffrey J. Critchfield, MD
Marco Cura, MD, FSIR
Jon C. Davidson, MD
Miguel A. De Gregorio, MD, EBIR, FSIR, FCIRSE
Kush R. Desai, MD
Peter Drescher, MD, MS
Aaron Dunn
Raisa Durrani, MD
David J. Eschelman, MD, FSIR
Salomao Faintuch, MD
Fabrizio Fanelli, MD
Adam S. Fang, MD
Tony Farrell, MD, MBA, FRCR
Brian Funaki, MD, FSIR
Ron C. Gaba, MD, FSIR
Ahmed Gabr, MD
Sameer D. Gadani, MD
Ripal T. Gandhi, MD
Suvranu Ganguli, MD, FSIR
Joseph Gemme, MD, FSIR, FACR, FAHA
Juan M. Gimenez, MD
Michael Ginsburg, MD
Christopher S. Goettl, MD, MBA
Antoinette S. Gomes, MD, FSIR, FACR, FAHA
Daniel Eugenio Gomez Ramos, DO
Carin F. Gonsalves, MD, FSIR
Assaf Graif, MD
Jared R. Green, MD
Carlos J. Guevara, MD
Marcelo Guimaraes, MD, FSIR
Ramona Gupta, MD
Sanjay Gupta, MD
Benjamin D. Hammelman, MD, MSED
Alisa Suzzi Han
Christopher M. Harnain, MD, MBA
Marshall Hicks, MD, FSIR
Cheryl H. Hoffman, MD
Eric J. Hohenwalter, MD, FSIR
Brian P. Holly, MD
Gloria L. Hwang, MD
Bertrand Janne d’Othee, MD, MPH, MBA
Hanna Javan, MD
Daniel Hyun Jin, MD
Almamoon I. Justaniah, MD
Sanjeeva P. Kalva, MD, FSIR
John A. Kaufman, MD, MS, FSIR
Stephen T. Kee, MD, MMM, FSIR
Alexander Y. Kim, MD
Charles Y. Kim, MD, FSIR
Hansol Kim, MD
Seung Kwon Kim, MD
George Kimbiris, MD
Srirish Kishore
Maureen Pearl Kohi, MD
Kevin Koo
Katharine L. Krol, MD, FSIR
Ghazwan M.F. Kroma, MD
Kopal Kulkarni, MD
William T. Kuo, MD, FSIR
Mark Le
Michael J. Lee, MD, FRCR, FSIR
Mark L. Lessne, MD
Robert J. Lewandowski, MD, FSIR
Robert P. Liddell, MD
Andrew Lipnik, MD
John D. Louie, MD
David C. Madoff, MD, FSIR
Bill Majdalany, MD
Naganathan B. Mani, MD
Roberto Marcello
Xhorlina Marko
Manuel Maynar, MD, FSIR
Gordon McLennan, MD, FSIR
Michael J. Miller JR., MD, FSIR
Jeet Minocha, MD
Alexander Misono, MBA, MD
Jason W. Mitchell, MD, MPH, MBA
Derek Mittleider, MD
Louis Maurice Morel-Ovalle, MD
Samdeep Mouli, MD, MS
Albert A. Nemcek Jr., MD, FSIR
Siddharth A. Padia, MD
Constantino S. Peña, MD, FSIR
Uei Pua, FRCR, FCIRSE
Dheeraj K. Rajan, MD, FRCP, FSIR
Howard M. Richard III, MD
Gerant Rivera-Sanfeliz, MD, FSIR
Paul J. Roehn, MD
Bahman Sayyar Roudsari, MD, PhD
Sharjeel H. Sabir, MD
Bahman Sadeghi
Kent T. Sato, MD, FSIR
Michael A. Savin, MD, FSIR
Brian J. Schiro, MD
Scott Schwartz, MD
Rajesh Shah, MD
Manrita Sidhu, MD
Sergio Sierre, MD, FSIR
James E. Silberzweig, MD, FSIR, FACR
Jason C. Smith, MD
Ravi Srinivasa, MD
Edgar St. Amour
Brian F. Stainken, MD, FSIR
Michael S. Stecker, MD, FSIR
Mark A. Sulfenfuss, MD
Rajeev Suri, MD
Patrick D. Sutphin, MD, PhD
Daniel Y. Sze, MD, PhD
Bedros Taslakian, MD
Jordan C. Tasse, MD
Sidhartha Tavri, MD
David W. Trost, MD, FSIR
Srini Tummala, MD
Ulku C. Turba, MD, FSIR
Raul Nimah Uppot, MD
Alexander R. Vogel, MD
David S. Wang, MD
Thomas J. Ward, MD
Sarah B. White, MD, MS
David M. Williams, MD, FSIR
Darryl A. Zuckerman, MD, FSIR
Scientific Session Objectives

As a result of attending scientific sessions, participants should be able to:

1. Analyze current research in interventional radiology
2. Identify current and future technical and clinical developments
3. Identify new research methods and areas requiring further investigation

The Society of Interventional Radiology is an accredited provider of continuing medical education through the Accreditation Council for Continuing Medical Education (ACCME) and is required to obtain disclosure statements from all presenters. It is SIR policy that presenters who currently have, or have had within the last 12 months, an affiliation or financial relationship with companies or organizations about whose products or services they are reporting (or discussing), disclose such affiliations and relationships to the audience.

In addition, in order to maintain high standards of professional integrity and ethics, SIR requires that faculty fully disclose to their audiences any discussion of the unlabeled use of a commercial product, device, or pharmaceutical that has not been approved for such purpose by the U.S. Food and Drug Administration (FDA). Presenters will be encouraged to include this information on their presentation slides. A list of presenters who have nothing to disclose will be available on site, as well as the specifics of the full disclosure, which the presenters have indicated.

Scientific abstracts

Abstracts for the 2018 Annual Scientific Meeting are listed by category as scientific presentations or posters. Posters are further categorized as scientific oral presentation or scientific ePosters. Four hundred will be presented in the scientific sessions and general session covering all areas of vascular and nonvascular interventional radiology. More than 670 abstracts will be on display as posters and ePosters located in the Los Angeles Convention Center. Attendees are invited to the Poster Reception on Tuesday, March 20, at 6 p.m., where poster authors will be available for questions and discussion.

Scientific sessions

Scientific sessions will be held Sunday, March 18, through Wednesday, March 21, at the Los Angeles Convention Center. During this time, authors representing 22 countries from the global IR community will present the latest scientific research in interventional radiology.

Distinguished abstracts

The Annual Scientific Meeting Committee has identified five abstracts as Distinguished Abstracts to be presented in selected scientific sessions. The Distinguished Abstract designation was created to highlight the best scientific work submitted to the meeting based on its overall quality, timeliness and content.

Continued in 2018! The Abstracts of the Year will be presented Sunday, March 18, during the plenary session. This year will feature two abstracts: the best overall clinical research and the best overall basic science.

Featured abstracts

The SIR 2018 Annual Scientific Meeting continues the tradition of designating exceptional abstracts in the Scientific Sessions as Featured Abstracts. These abstracts are identified with a gray outline on the following pages.

Scientific ePosters

Scientific ePosters are recognized by the Society of Interventional Radiology as an important part of the scientific program and are as highly regarded as presentations. Scientific ePosters and educational exhibits will be on display for review by meeting attendees Sunday through Wednesday during the meeting.

Poster Awards

Another continued feature of the SIR 2018 Annual Scientific Meeting will be the announcement of poster award recipients at the Scientific Poster Reception. Poster award recipients will be announced Tuesday, March 20, at 6 p.m.

SIR Foundation Research Grants and Awards

Denotes scientific abstracts from research partially or fully funded by SIR Foundation.
ABSTRACTS CHOSEN BY THE ANNUAL SCIENTIFIC MEETING COMMITTEE

In advance of the upcoming annual meeting of the Society of Interventional Radiology in Los Angeles, the program committee wishes to highlight the scientific abstracts that will be presented. Abstracts were chosen using blinded review. Authors are congratulated for their contributions.

The abstracts of the year, distinguished abstracts, and featured abstracts are designated as such.

Constantino S. Peña, MD, FSIR
Chair, 2018 Annual Meeting Scientific Program

Editorial Notes

Please note that the following abstracts are out of order due to scheduling changes: Nos. 254, 277, 362, 380, 386, 387, and 432.

Please also note that some tables are cited but not included in the text. Such tables were not supplied at abstract submission time.

Small portions of text may be missing in some abstracts due to the abstracts database malfunction. The missing text could not be recovered by press time.

ABSTRACTS OF THE YEAR

Plenary: Sunday Plenary

Sunday, March 18, 2018
10:30 AM–12:00 PM

Abstract No. 1

ABSTRACT OF THE YEAR
Randomized, double-blind placebo-controlled trial for evaluating safety and therapeutic efficacy of angiogenesis induced by intraarterial autologous bone marrow–derived stem cells in patients with critical limb ischemia
S. Sharma1, S. Kumar2, K. Nath2, S. Mohanty2, G. Gulati2, P. Jagia2; 1All India Institute of Medical Sciences, Delhi, Delhi; 2All India Institute of Medical Sciences, New Delhi, Delhi

Purpose: To evaluate safety and therapeutic efficacy of angiogenesis induced by intraarterial delivery of autologous bone marrow derived stem cells in patients with critical limb ischemia, not suitable for surgical or endovascular treatment.

Materials: Prospective, randomized, placebo-controlled double-blind trial was done comparing optimized medical therapy with therapeutic angiogenesis produced by intraarterial delivery of stem cell derived from autologous bone marrow. A total of 80 patients were randomized to group A (control group) receiving optimized medical therapy (cilostazol, aspirin, and analgesic for pain relief, attention to risk factors) and a sham intraarterial injection proximal to occlusion, and group B (study group) receiving intraarterial 60-100 million stem cells proximal to occlusion and optimized medical therapy. Primary end points—changes in the composite clinical status at 1, 3 and 6 months, including relief of rest pain, >50% improvement in pain free walking distance, >30% reduction in ulcer size; and reduction in major amputation rate. Secondary end points—improvement in ABI of ≥ 0.1, improvement in TcPO2 >15%, improvement in collateralization grade by at least 1 on imaging.

© SIR, 2018

*An underline under an author’s name designates the abstract presenter.

†In some abstracts, the authors’ names and affiliations are duplicated due to inconsistent affiliation listings by authors with the same affiliation. N/A in the author affiliation area indicates that no affiliation was available at press time.

Content current as of January 3, 2018.

ASM Abstracts Supplement Disclaimer Notice

SIR assumes no legal liability or responsibility for the completeness, accuracy, and correctness of the information presented in the abstracts. Abstracts will be published in the Annual Meeting Supplement to the Journal of Vascular and Interventional Radiology as submitted by the authors, except for minor stylistic adjustments to ensure consistency of format and adherence to Supplement style.

Dosages, indications, and methods of use for products that are referred to in the supplement by the authors may reflect their clinical experience or may be derived from the professional literature or other clinical sources. Because of the differences between in vitro and in vivo systems and between laboratory animal models and clinical data in humans, in vitro and animal data may not necessarily correlate with clinical results.
Results: There were 76 males with median age of 45 (range, 21-80) years. Technical success was achieved in 100% cases, without complication. Follow up information was available for 80 patients at 1-month, 68 patients at 3 months, 66 patients at 6 months and 64 patients at 1 year. There was improvement in pain free walking distance (25% in group A versus 70% in group B, p=0.006), relief of rest pain (34% in group A versus 67%, p=0.007) reduction in ulcer size (28% in group A versus 69% group B, p=0.004), reduction in major amputation rate (10% in group A versus 0% group B, p<0.05), improvement in ABI (17% in group A versus 72% in group B, p=0.004) and improved TcPO2 (5% in group A versus 70% in group B, p<0.001). Angiographic changes in collateral grade were not statistically significant.

Conclusions: Intra-arterial injection of autologous bone marrow-derived stem cell is safe and effective in the management of patients with critical limb ischemia not suitable for surgical or endovascular treatment.

Abstract No. 2

ABSTRACT OF THE YEAR

Sparing of collagen and extracellular matrix proteins in irreversible electroporation-treated normal porcine lung promotes T-cell and macrophage infiltration throughout ablated tissue

M. Fujimori1, E. Ueshima2, L. Vroomen3, D. Dupuy4, J. Erinjeri5, S. Solomon6, G. Srimathveeravalli7; 1Memorial Sloan Kettering Cancer Center, New York, NY; 2Kobe University, Kobe, Hyogo; 3VU University Medical Center, Amsterdam, NH; 4Brown University Rhode Island Hospital, Providence, RI; 5Memorial Sloan-Kettering Cancer Center, New York, NY; 6Memorial Sloan Kettering, New York, NY; 7Memorial Sloan Kettering Cancer Center, Kew Gardens, NY

Purpose: This study investigates the effect of irreversible electroporation on the extracellular matrix (ECM) of normal swine lung and its impact on T-cell and macrophage activity in the ablated tissue.

Materials: Normal swine lung was treated with IRE (n = 4), or microwave ablation (MWA, control) (n = 4), and animals were sacrificed at 2 or 28 days after treatment. Whole section samples of treated lung were stained with antibodies for collagen (Masson’s trichrome), ECM proteins (Decorin & Heparan Sulfate), T-cells (CD3), and macrophages (IBA1). Stained slides were analyzed with an image processing software (ImageJ) to count the number of positive staining cells or the percentage area of tissue staining positive for ECM, and the statistical difference was evaluated with Student’s t-test.

Results: Collagen staining (Masson’s trichrome) was reduced in both IRE and MWA treated samples at Day 2, with complete loss only in MWA samples at Day 28. Levels of Heparan Sulfate and Decorin in IRE samples were no different from normal lung, and were unmeasurable in the MWA (p<0.001). There was monotonous increase in T-cells everywhere within IRE samples (Day 2: 8.0 ± 2.71; Day 28: 25.6 ± 7.79, p<0.001). T-cells were restricted to the peri-ablation rim in MWA (Day 2: 6.9 ± 2.03; Day 28: 18.0 ± 7.07, p = 0.0002) and no cells were found within the ablation at Day 28. Macrophage infiltration and proliferation in IRE samples mirrored T-cells (Day 2: 8.5 ± 2.32, Day 28: 16.1 ± 4.75, p = 0.002), equivalent to the peri-ablation rim of MWA (Day 2: 3.0 ± 1.63, Day 28: 24.5 ± 8.07, p<0.0001) and were absent within the ablation itself in MWA samples (p<0.001).

Conclusions: IRE treated normal swine lung showed marked infiltration and proliferation of T-cells and macrophages from Day 2-28 posttreatment, which was absent in MWA samples. Collagen and ECM proteins that serve as chemokine-binding sites were preserved in IRE treated lung but completely destroyed in MWA, which may underlie infiltration of these cells throughout the ablation.
Scientific Session 1

Embolization: Prostatic Artery

Sunday, March 18, 2018
3:00 PM–4:30 PM
Room: 402B

3:00 PM Abstract No. 3

Changes in total gland and central zone volumes following prostate artery embolization: results from a prospective study

R. Ali, S. Mouli, F. Miller, A. Gabr, R. Mora, A. Al Asadi, N. Abouchaleh, J. Hairston, A. Riaz, R. Lewandowski, R. Salem; 1Northwestern University, Forest Park, IL; 2Northwestern University Feinberg School of Medicine, Chicago, IL; 3Northwestern University, Chicago, IL; 4Northwestern University, Chicago, IL; 5Northwestern Medicine, Chicago, IL

Purpose: To assess the change in volume of prostate and imaging findings following prostate artery embolization (PAE) for benign prostate hyperplasia (BPH).

Materials: With IRB approval, we analyzed prospectively acquired imaging data pre- and post-PAE at baseline and 6-months follow-up. The cohort studied in this analysis is part of an ongoing prospective clinical trial. We calculated the total volume (TV) and central zone volumes (CZ) of prostate using DynaCAD (Invivo Royal Philips, FL) and measured percentage change in volume following PAE. Additionally, post-PAE imaging changes including changes in signal intensity, enhancement, evidence of infection, and infarction were recorded. Data was compared using Fisher Exact test and paired t-test with a p-value of <0.05 considered significant.

Results: Thirty-two patients (n = 32) treated with PAE were included in our study. Median TV at baseline was 86 cc (range, 29.4-190.5) and 82 cc (range, 25.3-158.2) at 6 months post PAE. Median CZ at baseline was 54.4 cc (range, 12.9-165.5) and 48 cc (range, 7.1-131.6) at 6 months post PAE. Median decrease in TV was 19.9% (CI: 15.2-35.1) (p = 0.0001) and median decrease in CZ was 37.2% (CI: 23.7 – 56.9) (p = 0.0001). Larger prostates (>80 cc) had a more significant decrease in volume than smaller prostates (<80 cc) (p = 0.021). At 6-month follow-up imaging review, 28% (9/32) showed infarction, 84% (27/32) had decrease in T2-signal intensity, and 47% (15/32) showed decrease in enhancement. There were no imaging signs of infection following PAE.

Conclusions: This prospective study demonstrates that PAE produces significant reduction in TV. Interestingly, this is the first report of CZ volume reduction following PAE. These changes are most significant in patients with prostates > 80 cc in volume.

3:08 PM Abstract No. 4

Treating refractory hematuria of prostatic origin with prostate artery embolization: single-institution experience in 12 patients

S. Bhatia, S. Gomez, V. Sinha, S. Harward, C. Gomez, B. Kava, D. Parekh; 1University of Miami Miller School of Medicine, Miami, FL; 2University of Pennsylvania Perelman School of Medicine, Philadelphia, PA; 3The Dartmouth Institute for Health Policy and Clinical Practice, Arlington, MA

Purpose: To assess the safety and feasibility of prostate artery embolization (PAE) for refractory hematuria of prostatic origin (RHPO) in patients with benign prostatic hyperplasia (BPH) and in the post-surgical setting.

Materials: Between January 2014 and July 2017, an IRB-approved retrospective study of 12 patients who presented with RHPO was performed. Seven (58.3%) of these patients presented with RHPO secondary to a prior transurethral resection of the prostate (TURP), while 5 (41.7%) presented with BPH-associated RHPO. Medical treatment and continuous bladder irrigation were unsuccessful in resolving RHPO in all cases prior to PAE. Outcome included time to resolution of RHPO, Quality of Life (QOL) scores derived from the International Prostate Symptom Score (IPSS), prostate size via magnetic resonance imaging, and adverse events.

Results: RHPO resolved within 24-hours in 11 (91.7%) of the 12 cases. One patient continued to experience hematuria for 48-hours post-PAE, which subsequently resolved without further intervention. No patients required further transfusions or had further episodes of hematuria. QOL improved at 1 month, 3 months, 6 months, and 12 months from 4.3 to 1.8 (p = 0.114), 0.8 (p<0.005), 0.2 (p<0.005) and 0.0 (p<0.005), respectively. At 3 months follow-up, the average prostate volume was reduced to 139.2g from 201.7g (p<0.005). Minor, self-resolving adverse events included fever (16.7%), bladder spasms (7.8%), and access site ecchymosis (7.8%).

Conclusions: PAE is a safe and effective treatment option for BPH patients with RHPO, especially in those with postoperative hematuria.
Clinical outcomes measures in the use of prostate artery embolization for prostates ≥80 grams: a single-center experience in 110 patients

S. Bhatia1, V. Sinha1, S. Harward2, C. Gomez1, B. Kava1, D. Parekh1; 1University of Miami Miller School of Medicine, Miami, FL; 2The Dartmouth Institute for Health Policy and Clinical Practice, Arlington, MA

**Purpose:** To evaluate the efficacy of prostate artery embolization (PAE) for the treatment of benign prostatic hyperplasia (BPH) for prostates ≥80 g.

**Materials:** Patient demographics, International Prostate Symptom Score (IPSS), Quality of Life score (QOL), prostate volume assessed by MRI, maximum urinary flow (Qmax), and post-void residual (PVR) volume were evaluated as part of an IRB-approved retrospective analysis at a single institution. Exclusion criteria included patients with active urinary tract infection, renal failure, or severe atherosclerosis.

**Results:** Between January 2014 and September 2017, 110 patients underwent PAE for BPH with prostate size ≥80 g. Mean patient age was 69.0 years, mean baseline QOL was 4.7, and mean prostate volume was 153.7 g. At 1, 3, 6, and 12 months, QOL score improved to 1.6, 1.0, 0.9, and 1.1, respectively (p < 0.001 for all). At 3 and 12 months of follow-up, mean prostate volume had decreased to 105.4 g (p < 0.001) and 96.1 g (p < 0.001). Among the 85 (77.3%) patients non-reliant on bladder catheterization prior to PAE, mean baseline IPSS of 23.3 significantly improved to 8.2, 6.8, 6.1, and 7.6, at 1, 3, 6, and 12 months, respectively (p < 0.001 for all). In this same cohort, PVR volumes at baseline, 1 month, 3 months, 6 months, and 12 months were 193.2 mL, 50.7 mL, 88.1 mL, 91.0 mL, and 112.1 mL, respectively (p < 0.001 for all). Qmax also improved from a baseline of 7.6 mL/s to 13.1 mL/s (p < 0.001) at 3 months. In the 25 patients reliant on bladder catheterization prior to PAE, 21 (84.0%) were non-reliant on catheterization by 3 months post-PAE at a mean of 17.6 days post-embolization.

**Conclusions:** PAE achieved a clinically and statistically significant reduction in prostate size and an improvement in QOL in all patients with prostates ≥80 g. Among non-catheterized patients, IPSS and PVR volumes improved significantly. These findings suggest that PAE can be a valuable treatment option for BPH among men with ≥80g prostates when the conventional surgical options are limited and carry significant morbidity.

Prostate artery embolization (PAE) and prostatic urethral lift (PUL) procedures for symptomatic benign prostatic enlargement (BPH): a retrospective, single-center comparison of outcomes

K. Pereira1, S. Ford-Glanton2, R. Johar2, P. Xu2, K. Pham3, S. Gadani3, A. Fang3, J. Kao3, L. Morel-Ovalle3, A. Hal4, K. Vaheesan3; 1Saint Louis University, Vascular & Interventional Radiology, St. Louis, MO; 2Saint Louis University, Urology, St. Louis, MO; 3Saint Louis University, Vascular & Interventional Radiology, St. Louis, MO; 4Saint Louis University, Biomedical Engineering, St. Louis, MO

**Purpose:** Current data shows that PUL and PAE represent two evolving, minimally invasive techniques in the treatment of symptomatic BPH. Comparative studies of these techniques are lacking; we aim to compare outcomes of PUL and PAE.

**Materials:** All patients undergoing PAE or PUL were retrospectively identified in this single-center, IRB approved study. The international prostate symptoms score (IPSS) and quality of life (QOL) score were compared between PAE and PUL groups at baseline, 3 months, and 6 months. A repeated measures ANOVA predicting IPSS from procedure type and QOL from procedure type were performed.

**Results:** The initial sample included 37 patients (PAE: 21; PUL: 16). Baseline IPSS scores were 25.2 ± 7.0 in PAE group (n = 21) and 21.7 ± 8.955 in PUL group (n = 16). At 3, 6-month follow-up, IPSS was 13.5 ± 7.6 (n = 16), 15.2 ± 9.2 (n = 10) in the PAE group and 11.5 ± 5.7 (n = 14), 12.7 ± 8.9 (n = 12) in the PUL group. There was no overall difference in IPSS scores due to either procedure (p = .13), and no procedure by time interaction (p = .34). However, a significant time effect was observed (p < .01) such that both procedures produced immediate IPSS score reductions, and each reduction held over time. Baseline QOL scores were 5.1 ± 0.9 in PAE group (n = 20) and 4.09 ± 2 in PUL group (n = 11). At 3, 6-month follow-up QOL was 2.1 ± 1.5 (n = 12), 2.5 ± 1.7 (n = 8) in the PAE group and 2.7 ± 1.6 (n = 13), 2.7 ± 1.3 (n = 11) in the PUL group. There was no overall difference in QOL due to procedure (p = .48). However, a significant time effect was observed (p = .05). This effect was driven by a significant procedure by time interaction (p = .05) such that PUL had little effect on QOL scores across time, but PAE produced an immediate QOL reduction, which was persistent over time.

**Conclusions:** Preliminary findings suggest that PAE and PUL are equally effective at reducing and maintaining IPSS; PAE may offer additional benefits in terms of maintaining QOL. Plan for a prospectively analysis of matched cohorts with a larger sample size are currently underway to help better understand procedure based outcomes and safety profile. (clinicaltrials.gov NCT03043222)

Prostate artery embolization for chronic and recurrent urinary tract infections associated with benign prostatic hypertrophy

S. Bhatia1, S. Gomez2, S. Shaikh3, V. Sinha4, I. Kably5; 1University of Miami, Davie, FL; 2N/A, Philadelphia, PA; 3Jackson Memorial Hospital/University of Miami Health System, Miami, FL; 4University of Miami Miller School of Medicine, Miami, FL; 5University of Miami, Miami, FL

**Purpose:** Benign prostatic hypertrophy (BPH) increases the risk of acquiring chronic and recurrent urinary tract infection (UTI) due to urinary stasis. Medical management may be difficult, as these infections are often associated with antibacterial resistance and 5-alpha reductase inhibitors have not been shown to be effective at prevention. Transurethral resection of the prostate carries the risks of surgery and increases the risk of a postoperative infection. Prostate artery embolization (PAE) is a new minimally invasive treatment option for patients with symptomatic BPH. Its role in the management of chronic and recurrent UTI after failed medical therapy has not been reported yet. We report on the technical and...
clinical outcomes of 4 patients with BPH complicated by chronic and recurrent UTI. 

Materials: After institutional board review approval, a review of the medical record of 96 patients undergoing prostate artery embolization between January 2014 and July 2016 was performed. Technical success was defined as bilateral prostatic artery embolization to hemostasis. The total number of UTI in a 12-month period was reported. Clinical outcomes were recorded at 6 months following PAE and included recurrence of UTI, International Prostate Symptom Score (IPSS), quality-of-life due to urinary symptoms (QOL), and reduction in prostate size by MR imaging at 3 months. 

Results: A total of 4 patients were identified with a mean age of 72. Technical success was 100%. The mean number of UTI was 5.5. There were no recurrences of UTI. All patients demonstrated an improvement in their IPSS and QOL scores. All patients demonstrated a significant improvement in prostate volume with a pre-procedural mean size of 132.8 g and a postprocedural mean size of 87.1 g. Results are summarized in Table 1. 

Conclusions: PAE is a novel treatment option for patients with chronic and recurrent UTI associated with BPH. Further studies with larger patient cohorts are necessary to validate the findings reported in this case series.

### Table 1.

<table>
<thead>
<tr>
<th>Patient Number</th>
<th>UTI Preprocedure</th>
<th>UTI Postprocedure</th>
<th>Baseline IPSS</th>
<th>Postprocedural IPSS</th>
<th>Baseline QOL</th>
<th>Postprocedural QOL</th>
<th>Baseline Size (g)</th>
<th>Postprocedural Size (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>0</td>
<td>29</td>
<td>16</td>
<td>5</td>
<td>3</td>
<td>153</td>
<td>104</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>144</td>
<td>96</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0</td>
<td>11</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>130</td>
<td>78</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>0</td>
<td>21</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>104</td>
<td>70.2</td>
</tr>
</tbody>
</table>

3:40 PM Abstract No. 8

**Prostatic artery embolization for benign hyperplasia: outcome after the 1-year follow-up in 40 consecutive cases performed at a single center**

N. Kisilevzky1, D. Ekizian2, P. Lylyk2; 1Clinica Sagrada Familia, Buenos Aires - Argentina; 2Clinica Sagrada Familia, Buenos Aires, CABA; 3Neurosurgery, Buenos Aires, Argentina

**Purpose:** To present the outcome observed after a 1-year follow-up of a series of 40 patients with benign prostate hyperplasia treated consecutively with prostatic artery embolization as an alternative to surgery.

**Materials:** Between January 2015 and August 2016, 40 patients (mean age 62.3 years) with lower urinary tract symptoms due to benign prostatic hyperplasia and refractory to medical therapy underwent prostatic artery embolization. All patients were evaluated with specific questionnaires to determine the severity of symptoms and impact on quality of life and erectile function, pelvic ultrasound and MRI, urinary flowmetry, and PSA before the procedure (baseline) and 30 days and 1 year after the procedure. Procedures were performed in an outpatient condition with local anesthesia and mild sedation through the right femoral vascular access. Tris-acryl gelatin microspheres in the range of 300–500μm were used as an embolic agent in all cases.

**Results:** Embolization was successful in all patients; in 36 cases, embolization was achieved bilaterally. The average time for completion of the procedure was 65 minutes with mean radiation time of 28.2 minutes. Various anatomical origins of the PA were found. Cone-beam CT was used in 29 cases whether to confirm or to discard the prostatic artery for delivering the embolic agent. At 30 days it was observed a mean reduction of 25.3% in prostate volume, 6.1-point improvement in IPSS, 2 point improvement in QOL, and 3 point improvement in IIEF. The peak urinary flow improved by 46% and PSA dropped 42%. No major complications. Minor adverse events were verified and easily resolved in 14 patients. Seven patients (17.5%) needed to continue their medication and were considered unsuccessful cases. At the 1-year follow-up, there were no significant changes in clinical parameters in comparison to those observed after 30 days. At that time, 13 patients (32.5%) needed to continue medication.

**Conclusions:** Prostatic artery embolization as an alternative treatment to surgery for patients with BPH and LUTS was safe and effective in improving symptoms. Most clinical improvement was observed during the initial 30 days post procedure and remained for 1 year in approximately 70% patients.

3:48 PM Abstract No. 9

**Prostate artery embolization for prostate volumes ≥ 80g vs. <80g - clinical outcomes from a single institution**

S. Bhatia1, V. Sinha1, S. Harward2, C. Gomez1, B. Kava1, D. Parekh1; 1University of Miami Miller School of Medicine, Miami, FL; 2The Dartmouth Institute for Health Policy and Clinical Practice, Arlington, MA

**Purpose:** To compare the efficacy of prostate artery embolization (PAE) for the treatment of benign prostatic hyperplasia (BPH) for prostates ≥80 g and prostates <80 g.

**Materials:** An IRB-approved retrospective analysis was conducted for patient demographics, International Prostate Symptom Score (IPSS), quality of life (QOL) score, maximum urinary flow (Qmax), prostate volume assessed by MRI, and post-void residual (PVR) volume at a single institution.

**Results:** Between January 2014 and August 2017, 95 patients underwent PAE with prostate sizes less than 80g. The two cohorts did not significantly differ in age (p = 0.12) or PAE indication (p>0.20). Clinical baseline and follow-up visit data are outlined in Table 1.

**Conclusions:** Patients in both groups achieved similar objective Qmax and PVR results post embolization, but those with prostates...
≥80g perceived better symptom relief (based on IPSS score) and QOL after PAE.

### Table 1. PAE Baseline and Follow-up

<table>
<thead>
<tr>
<th>Outcome</th>
<th>&lt;80 g</th>
<th>≥80 g</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPSS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>26.1</td>
<td>23.6</td>
<td>0.03</td>
</tr>
<tr>
<td>3 months</td>
<td>11.5</td>
<td>6.6</td>
<td>0.02</td>
</tr>
<tr>
<td>6 months</td>
<td>9.8</td>
<td>6.1</td>
<td>0.01</td>
</tr>
<tr>
<td>12 months</td>
<td>8.5</td>
<td>6.8</td>
<td>0.18</td>
</tr>
<tr>
<td>QoL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>4.9</td>
<td>4.7</td>
<td>&gt;0.20</td>
</tr>
<tr>
<td>3 months</td>
<td>2.0</td>
<td>1.0</td>
<td>0.002</td>
</tr>
<tr>
<td>6 months</td>
<td>1.9</td>
<td>0.9</td>
<td>0.004</td>
</tr>
<tr>
<td>12 months</td>
<td>1.5</td>
<td>1.1</td>
<td>&gt;0.20</td>
</tr>
<tr>
<td>Qmax (mL/s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>7.9</td>
<td>7.6</td>
<td>&gt;0.20</td>
</tr>
<tr>
<td>3 months</td>
<td>11.8</td>
<td>12.6</td>
<td>&gt;0.20</td>
</tr>
<tr>
<td>6 months</td>
<td>11.1</td>
<td>14.0</td>
<td>&gt;0.20</td>
</tr>
<tr>
<td>12 months</td>
<td>12.6</td>
<td>9.6</td>
<td>0.15</td>
</tr>
<tr>
<td>PVR (mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>128.7</td>
<td>231.6</td>
<td>0.001</td>
</tr>
<tr>
<td>3 months</td>
<td>106.0</td>
<td>73.9</td>
<td>&gt;0.20</td>
</tr>
<tr>
<td>6 months</td>
<td>116.8</td>
<td>92.9</td>
<td>&gt;0.20</td>
</tr>
<tr>
<td>12 months</td>
<td>56.4</td>
<td>86.9</td>
<td>&gt;0.20</td>
</tr>
<tr>
<td>Prostate Volume (mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>54.7</td>
<td>157.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3 months</td>
<td>39.4</td>
<td>105.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>12 months</td>
<td>36.5</td>
<td>96.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prostate Volume Reduction (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 months</td>
<td>26.6</td>
<td>32.6</td>
<td>0.07</td>
</tr>
<tr>
<td>12 months</td>
<td>35.7</td>
<td>29.5</td>
<td>&gt;0.20</td>
</tr>
</tbody>
</table>

### 4:04 PM Abstract No. 11

Cone-beam CT with embolization guidance software vs. standard cone-beam CT during prostate artery embolization: effect on radiation dose

O. Shoai1, I. Livshits2, S. Lekperic3, M. Ranade2, V. Bishay2, R. Patel5, E. Kim5, F. Nowakowski5, R. Lookstein2, A. Rastinehad4, A. Fischman7; 1Icahn School of Medicine at Mount Sinai, New York, NY; 2Mount Sinai Hospital, New York, NY; 3NJ/A, Staten Island, NY; 4Icahn School of Medicine at Mount Sinai Hospital, New York, NY; 5Mount Sinai Medical Center, New York, NY; 6Icahn School of Medicine at Mount Sinai Department of Urology, New York, NY; 7Icahn School of Medicine at Mount Sinai, New York, NY

**Purpose:** To evaluate the difference in radiation exposure to the patient during prostate artery embolization (PAE) utilizing cone beam CT (CBCT) with embolization guidance software versus the use of standard CBCT alone.

**Materials:** A retrospective analysis of PAE from 4/2015 to 9/2017 was performed. Exclusion criteria included technical failure (0 prostatic arteries embolized) and non-utilization of CBCT. All cases were performed utilizing Philips AluraClarity™ hardware. A total of 13 cases were included, with 9 procedures utilizing embolization guidance software (Philips EmboGuide™) and 4 procedures utilizing conventional CBCT alone. The mean age and BMI of the embolization guidance software group and standard CBCT group was 68.6 years, 25.4 kg/m² and 63.7 years, 30.6 kg/m², respectively. An independent-sample T test was used to compare the mean fluoroscopy time (FT), dose-area product (DAP) fluoroscopy, DAP exposure, DAP cumulative, contrast dose, and procedure time.
Results: A statistically significant difference was seen between the standard CBCT group and the embolization guidance software group for DAP exposure and DAP Cumulative dose. No difference was seen in the remaining variables. See Table 1.

Conclusions: CBCT with embolization guidance software allows for reduced radiation dose (DAP) to the patient compared to CBCT alone.

Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Embolization Guidance Software (n = 9)</th>
<th>Standard CBCT (n = 4)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluoroscopy time (min)</td>
<td>48.5</td>
<td>46.2</td>
<td>0.87</td>
</tr>
<tr>
<td>DAP fluoroscopy (mGy * cm²)</td>
<td>174,704</td>
<td>372,357</td>
<td>0.085</td>
</tr>
<tr>
<td>DAP exposure (mGy * cm²)</td>
<td>246,330</td>
<td>476,970</td>
<td>0.033</td>
</tr>
<tr>
<td>DAP cumulative (mGy * cm²)</td>
<td>426,258</td>
<td>78,1381</td>
<td>0.047</td>
</tr>
<tr>
<td>Contrast dose (cc)</td>
<td>108.9</td>
<td>125</td>
<td>0.75</td>
</tr>
<tr>
<td>Procedure time (min)</td>
<td>88.8</td>
<td>105</td>
<td>0.64</td>
</tr>
</tbody>
</table>

4:20 PM Abstract No. 432

Prospective single-center investigational device exemption study of prostate artery embolization for lower urinary tract symptoms

S. Mouch1, A. Riaz2, A. Gabr3, R. Ali4, F. Miller5, N. Hamoudi6, J. Lewandowski6, J. Haiston7, R. Salem8; 1Northwestern University Feinberg School of Medicine, Chicago, IL; 2Northwestern Medicine, Chicago, IL; 3Northwestern University, Forest Park, IL; 4Northwestern University, Chicago, IL; 5N/A, Chicago, IL

Purpose: To evaluate the safety and efficacy of prostate artery embolization (PAE) for the treatment of lower urinary tract symptoms (LUTS) attributed to benign prostatic hyperplasia (BPH).

Materials: A prospective, single-center, open-label FDA-approved study was conducted to evaluate the safety and efficacy of PAE for the treatment of LUTS secondary to BPH. Enrolled patients included men ≥45, prostate volume 40-90g, International Prostate Symptom Score (IPSS)>13, peak flow rate (Qmax) ≤ 12mL/s, and voided volume ≥125mL. Arterial embolization was performed with 300-500μm particles. Patients were evaluated with questionnaires [IPSS, quality of life (QoL), International Index of Erectile Function (IIEF), and Male Sexual Health Questionnaire for Ejaculatory Dysfunction (MSHQ-EjD)] and clinical measures [post-void residual volume (PVR), Qmax, prostate-specific antigen (PSA), and prostate volume (PV)] at screening/baseline, 1 month, 3 months, 6 months, and 1 year after PAE.

Results: 42 patients (PV 38-190 g) were treated over the course of the 3-year study. At six months and 1 year after treatment, there were statistically significant improvements in IPSS (Baseline 23.1 ± 2.1, 6-month 11.9 ± 3.1, 1 year 12.7 ± 3.0), and QoL (Baseline 4.8 ± 0.3, 6-month 2.4 ± 0.6, 1 year 2.8 ± 0.7). There were significant improvements in Qmax at 3 months post-PAE (Baseline 7.6mL/s ± 2.5mL/s, 3-month 15.4 mL/s ± 4.4 mL/s). No significant changes in IIEF-EF, MSHQ-EjD, PVR, or prostate volume were observed (p=0.39, p=0.88, p=0.07, and p=0.06, respectively). Adverse events include dysuria (n=13), hematuria (n=6), hematospermia (n=2), retrograde ejaculation (n=2), urinary frequency (n=3), and urinary retention (n=2). No severe adverse events or non-target embolizations have occurred.

Conclusions: Results from this prospective clinical trial demonstrate that PAE is a safe and effective treatment for BPH, with statistically significant improvement in LUTS.
Scientific Session 2

Embolization: Trauma

Sunday, March 18, 2018
3:00 PM–4:30 PM
Room: 404A

3:00 PM Abstract No. 13

Predictors of positive angiography in trauma patients with negative CT
E. Priddy1, D. Coldwell2, M. Potts1; 1University of Louisville, Louisville, KY; 2University of Louisville, Prospect, KY

Purpose: To identify predictive factors of pelvic extravasation at arteriography despite negative CT imaging in polytrauma patients.

Materials: Retrospective review of trauma patients admitted to a level I trauma center from 2010 to July 2017. Included patients were required to have undergone pelvic angiography preceded by contrast-enhanced CT demonstrating no contrast extravasation (CE). Pertinent imaging studies were reviewed to obtain the radiographic variables, which were analyzed in addition to the patient clinical data (Table 1).

Results: Pelvic angiography was performed on 216 trauma patients over the 7-year period, including 28 patients (13%) with precedent negative CT imaging. These patients were predominantly male (64%, n = 18) and ranged in age from 18-77 years (mean = 46). Most patients were injured in a motor vehicle crash (54%, n = 15), with other mechanisms including pedestrian vs car, fall/jump from height, motorcycle crash, and crush injury. 15 patients (54%) with no CE on CT had active pelvic arterial extravasation at angiography. Retropubic space hematoma on CT (p = 0.016) and tachycardia at arrival (p = 0.024) were significantly associated with CE at angiography. When controlling for Revised Trauma Score (RTS) and aortic density on CT with multivariate analysis, both retropubic space hematoma (OR = 12.40, 95% CI = 1.21-127.27, p = 0.034) and tachycardia (OR = 0.119, 95% CI = 0.017-0.814, p = 0.030) remained significant.

Conclusions: Prompt detection of ongoing hemorrhage allows for critical early intervention in polytrauma patients. Retropubic hematoma on CT and tachycardia at presentation may aid in early stratification of patients who are more likely to benefit from arteriography, with the potential to reduce trauma related mortality.

Table 1.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.705</td>
</tr>
<tr>
<td>Gender</td>
<td>0.433</td>
</tr>
<tr>
<td>Mechanism</td>
<td>0.700</td>
</tr>
<tr>
<td>GCS</td>
<td>1.000</td>
</tr>
<tr>
<td>RTS</td>
<td>0.410</td>
</tr>
</tbody>
</table>

3:09 PM Abstract No. 14

When does an osseous pelvic injury require embolization? An exploratory analysis to identify predicting factors for embolization compare those managed with diagnostic angiography only
B. Bones1, S. Burner1, E. White1, D. Smith2, J. Hoth1, P. Miller1, K. Dickey1; 1Wake Forest University School of Medicine/Baptist Medical Center, Winston Salem, NC; 2Wake Forest University School of Medicine, Winston Salem, NC

Purpose: Protocoled management of trauma improves outcomes in the “golden hour”; however, they need to be continuously reviewed as diagnostic technology improves. As the standard resolution of an axial CT has decreased from 5 mm to 0.63 mm, and thus less volume averaging, “contrast blush” or “extravasation” on newer scanners may not equate to its historical severity. The goal of our study is to identify factors, from both initial clinical presentation and CT interpretation on contemporaneous technology, that predict the need for embolization after osseous pelvic injury.

Materials: We conducted a review of pelvic injuries at our institution from 2014 to 2015. Cases were excluded if angiography was performed for another reason (e.g., splenic trauma), incomplete data, or death on day of injury. Factors such as age, injury severity scale, blood pressure, and gender were obtained from the trauma registry. Other factors such as fracture and joint injury,
extravasation and hematoma were coded from the original trauma and dedicated pelvic CTs. Data was analyzed using a Categorical Principal Component Analysis (CatPCA) and Multinomial Logistic Analysis.

Results: Two hundred and sixty-eight cases were included, with 20 undergoing embolization and 7 that had diagnostic angiography only. CatPCA identified 9 different possible dimensions ($\lambda > 1$), of which 5 where significant ($p = 0.5$) predicting embolization include age, injury severity scale, extravasation and pseudoaneurysm, injury to sacroiliac joints and pubic symphysis, and iliac fractures. Components with highest correlation to diagnostic angiography only include obturator ring, acetabular, and proximal femur fractures, hemarthrosis, pelvic organ and intramuscular hematoma.

Conclusions: Exploratory analysis with CatPCA may be used to identify factors that predict the need for embolization in osseous pelvic trauma. Models may be formulated from the resulting analysis to provide a clinical score to aid in protocolled management of pelvic trauma.

3:18 PM Abstract No. 15

Predictors of vascular injury on angiography in hemodynamically stable pelvic trauma patients
M. Abad-Santos1, S. Liu1, A. Shahverdiani2, T. Tanoura1, A. Moazzez2, D. Kim1; 1Harbor-UCLA Medical Center, Torrance, CA; 2SUNY Downstate Medical Center, Princeton, NJ

Purpose: Among hemodynamically stable patients with pelvic fractures, various clinical and radiographic findings may guide therapeutic intervention including the use of selective embolization. Given the time and resources that are required to mobilize the interventional radiology team, early identification of patients at risk for persistent hemorrhage is critical. The purpose of this study is to identify clinical and radiographic findings predictive of vascular injury on angiography among hemodynamically stable patients presenting with pelvic trauma.

Materials: A 6-year retrospective cohort analysis of adult patients with pelvic trauma who underwent both a contrast-enhanced CT of the abdomen/pelvis and a conventional angiogram was performed by reviewing electronic medical records. Patients without evidence of arterial injury on angiography were compared to those with such injuries. Variables analyzed included demographics, injury severity, complications, and mortality. CT scans were analyzed for the presence of hemorrhage, extravasation, pseudoaneurysm, and arteriovenous fistula. Angiographic images were reviewed for findings consistent with vascular injury: contrast extravasation, pseudoaneurysm, arteriovenous fistula, vessel truncation, filling defect, and hyperemia. Multivariate analysis was performed to identify independent predictors of vascular injury on angiography.

Results: Of 105 patients, 95 (90%) met inclusion criteria. The mean (SD) age of patients was 49 (20.5) years with 69 males and 26 females. On bivariate analysis, 3 or more positive CT findings ($p = 0.05$), Injury Severity Score ($p = 0.001$), AIS-Abdomen score of 3 ($p = 0.001$), and AIS-Extremity ($p = 0.031$) correlated with positive angiographic findings. On multivariable regression analysis, the presence of at least 3 positive CT findings (OR: 3.8 95% CI: 1.1-13.4 p = 0.037) and AIS-Abdomen score (OR: 1.5, 95% CI: 1-2.3, p = 0.036) were independent predictors of positive angiographic findings.

Conclusions: In hemodynamically stable patients with pelvic fractures, an AIS-Abdomen score of 3 or more and at least 3 positive CT findings should be considered for angiographic embolization.

3:27 PM Abstract No. 16

Relationship of embolic material choice and selectivity of embolization to short-term complications after arterial embolization for pelvic trauma
C. Ghazi1, E. Priddy1, L. Dinglasan2; 1University of Louisville Radiology Department, Louisville, KY; 2University of Louisville, Prospect, KY

Purpose: To examine whether choice of embolic material or selectivity of arterial embolization affects complications in the treatment of pelvic hemorrhage in trauma patients.

Materials: An IRB-approved, single-institution retrospective review of trauma patients undergoing pelvic embolization was performed. Patient medical records were reviewed for short-term complications, including gluteal, bladder, rectal, skin or femoral head necrosis, deep soft tissue infection, and incision breakdown. Complication rates were compared between patients subdivided based on embolic material (coils or gel foam (GF)) or vessel selectivity (nonselective (internal iliac), divisional (anterior or posterior), or superselective) utilizing the Chi-square test.

Results: From January 2010 to July 2017, 59 trauma patients underwent bilateral pelvic embolization, including 6 patients who died from immediate complications related to their trauma. Of the 53 remaining patients, 38 were male and 15 were female, with average age of 48 years. Injury mechanisms included motor vehicle crash (n = 19), motorcycle crash (n = 13), pedestrian vs. car/tractor (n = 13), falljump (n = 4), or crush injury (n = 4). 8% of patients (n = 4) developed complication(s), including gluteal necrosis (n = 2), skin necrosis (n = 2), deep infection (n = 3), and incision breakdown (n = 1). For comparative analysis by embolic material, patients were subdivided into 4 groups: coils to bilateral nonselective/divisional (n = 10), GF to bilateral nonselective/divisional (n = 26), coils and GF to bilateral nonselective/divisional (n = 8), and coils/GF to bilateral superselective (n = 9). For analysis based on embolization selectivity, patients were subdivided into 3 groups: bilateral nonselective/divisional (n = 33), unilateral nonselective/divisional (n = 12), and bilateral superselective (n = 8). There were no statistically significant differences in short-term complications when stratified by embolic material or arterial selectivity.

Conclusions: In the setting of pelvic embolization for traumatic pelvic hemorrhage, short-term complications are infrequent and not significantly impacted by choice of embolic material or arterial selectivity.
3:36 PM  Abstract No. 17

Blunt trauma in children: efficacy and safety of transarterial embolization: 4-year experiences in a single trauma center
H. Kwon1, C. Kim1, C. Jeon1; 1Pusan National University Hospital, Busan, Korea

Purpose: Transarterial embolization in blunt abdominal and pelvic injuries has been an important component of adult trauma care algorithm. Clinically, the major mechanism of trauma in children is blunt injury. However the role of transarterial embolization in the care of pediatric trauma is not firmly established. The purpose of this study was to evaluate the efficacy and safety of transarterial embolization by analyzing blunt trauma data of pediatric patients experienced at our trauma center.

Materials: A retrospective analysis was performed of all angiography data (age<18) with pediatric blunt injury admitted to our regional trauma center from October 2013 to September 2017. Patient data from the Korea Trauma Data Bank (KTDDB), and patients’ electrical medical records were reviewed for site of injury, injury severity score (ISS), evidence of ongoing hemorrhage, initial vital signs, and use of transarterial embolization. Presence of additional injury and overall hospitalization, transfusion requirement, and complications were also evaluated. Technical success was defined as the complete disappearance of the angiographic findings of bleeding on post-embolization angiography. Clinical success was defined as hemodynamic stabilization after transarterial embolization without additional surgery or second session angiography for bleeding control. To identify predictor of clinical success or failure, patients were divided into two groups based on definition of clinical success. Independent T test and Mann-Whitney U test were used for statistical analysis by SPSS 19.0.

Results: Twenty-seven children were included. The median age was 12 years and the median weight was 34 kg. And the mean Injury Severity Score was greater than 15 in 83% of patients. All of the patients underwent angiography and embolization for hemothasis. Technical success was achieved in all patients and clinical success was achieved in 88% of patients. Two patients experienced two complications (one major, one minor) potentially related to transarterial embolization.

Conclusions: In summary, angiography and transarterial embolization are safe and effective at controlling hemorrhage in pediatric blunt trauma.

3:45 PM  Abstract No. 18

Outcomes of proximal versus distal splenic artery embolization for traumatic and nontraumatic indications
A. Cortes1, J. Kim2, C. Commander3, K. Devulapalli4, U. Nag5, K. Kim2; 1University of North Carolina– Chapel Hill, Chapel Hill, NC; 2UNC School of Medicine, Chapel Hill, NC; 3University of North Carolina, Chapel Hill, NC; 4University of California San Francisco, San Francisco, CA; 5Duke University, Durham, NC

Purpose: The purpose of this study was to assess outcomes of splenic artery embolization with respect to proximal versus distal embolization technique for both nontraumatic and traumatic indications. A meta-analysis on this topic from the Journal of Trauma in 2011 specifically focused on outcomes data with respect to splenic artery embolization for trauma. However, there is a continued relative paucity of data with reference to outcomes parameters post splenic artery embolization for the myriad additional indications for which the technique is employed.

Materials: An IRB-approved retrospective study of splenic artery embolization performed in 104 patients over a time period of 17 years was undertaken. Pre- and post-splenic artery embolization data were interrogated via chart reviews. Data included: patient demographics, indications, site of embolization, embolic agents, complications (rebleeding, splenic infarcts, infections), and subsequent interventions (nominal medical therapies, percutaneous interventions, repeat embolization, surgical interventions). A comparative statistical analysis was performed.

Results: A statistically significant association of infections with utilization of Gelfoam or particles was demonstrated. Rates of major complications, in particular rebleeding, were exceedingly low overall. Rates of minor complications, chiefly splenic infarcts, were more frequent. There was no statistical difference between proximal versus distal embolization technique for major or minor complications. There was a trend towards a higher incidence of infections with distal technique.

Conclusions: A statistically significant association of infections with utilization of Gelfoam or particles was demonstrated. This suggests alternate embolics such as coils or plugs should be considered first-line. The overall incidence of complications was seemingly too low in our cohort to demonstrate a statistical difference between proximal and distal embolization technique. A trend towards a higher incidence of infections was noted with distal technique. A future meta-analysis may aid in shedding more light on outcomes of proximal versus distal splenic artery embolization for all contemporary indications.

3:54 PM  Abstract No. 19

Implementation of the EAST guidelines for splenic trauma: comparing outcomes of splenic artery embolization and splenectomy at a large level 1 trauma center
A. Dabrowiecki1, A. Subramanian1, R. Gelbard1, J. Martin1, S. Dariushnia1; 1Emory University School of Medicine, Atlanta, GA

Purpose: The 2012 EAST blunt splenic injury (BSI) guidelines recommend angiography for BSI grade ≥ 3 and highlight the relationship between higher grade splenic injury and complications with non-operative management. Since implementation of these guidelines, many studies show splenic artery embolization (SAE) to be safe and effective. With collaboration between IR and the trauma service at our level 1 trauma center, we retrospectively reviewed outcomes of splenectomy and SAE in relation to grading and varying SAE techniques.

Materials: From 9/1/2011 to 3/1/2017 we identified 86 splenectomy and 30 SAE patients after BSI, specifically motor vehicle collisions, gunshot wounds, falls, and assaults. AAST grading was recorded on CT imaging and intraoperatively. Review of SAE technique was performed by a single IR for consistency and major
Splenic artery embolization is a common procedure.

**Purpose:**
K. Singh1, A. Batouli2, D. Buck3; 1Allegheny General Hospital, Pittsburgh, PA; 2Allegheny Health Network, Pittsburgh, PA; 3University of California San Francisco, San Francisco, CA

**Splenic artery embolization: does severity of injury, type of embolic agent used, or location of embolization affect outcomes?**

**Materials:** A retrospective study was performed of patients with blunt splenic trauma who underwent splenic angiography between March 2014 and September 2017. Splenic injury was graded using the American Association for the Surgery of Trauma classification. Angiographic data regarding diagnostic findings, technical success, type(s) of embolic agent used and location of embolization were recorded. The electronic medical record was reviewed to determine demographics, clinical success and procedure complications. Clinical success was defined by resolution of bleeding after embolization and avoidance of splenectomy.

**Results:** Sixty-five patients were identified (39 men and 26 women), with an average age of 47 (range, 16 – 95) years. 57 out of the 65 patients underwent embolization. There were 2 Grade I, 7 Grade II, 31 Grade III, 14 Grade IV, and 3 Grade V injuries. 17 patients were embolized for extravasation and 40 patients underwent prophylactic embolization. Embolization was performed at proximal (main splenic artery), distal (selective) and both locations in 31, 17 and 9 patients respectively. In active extravasation group, 8 patients were embolized distal and 5 were embolized both proximal and distal. In prophylactic embolization group, 9 patients were embolized distal and 4 were embolized both proximal and distal. 22 patients were embolized using coils, 10 using Amplatzer plug, 9 using PVA particles, 3 using Gelfoam, and 13 using various combinations. Clinical success was similar (>80%) across all embolization locations, embolic agents and grades of lacerations.

**Conclusions:** Success rates may be similar in all grades of splenic injury regardless of type of embolic agent and location of embolization.

**4:03 PM Abstract No. 20**

Splenic artery embolization after trauma alters the natural course of splenic recovery

C. Zinsmeister1, L. Yen1, A. Carrier2, P. Miller3, B. Bones4; 1Wake Forest University School of Medicine, Winston Salem, NC; 2Eastern Carolina University, Greenville, NC; 3Wake Forest University School of Medicine/Baptist Medical Center, Winston Salem, NC

**Purpose:** Previously, we demonstrated that the infection rate after angioembolization (IR) and splenectomy were similar, and significantly greater than those managed by clinical observational (Obs). While current research is inconclusive regarding the anatomic and physiologic outcomes after splenic artery embolization, we hypothesize that the increased risk of infection has a statistically significant interaction with residual spleen size after IR when compared to Obs.

**Materials:** We retrospectively reviewed all splenic injuries at our institution from 2005 to 2010. Cases were excluded if age 30 days, and absence of a follow-up CT performed for any reason that did not include the entire spleen. A priori variable of interest included splenic index at the time of injury and on follow-up imaging, calculated as the product of the largest X, Y, and Z dimensions of the spleen. Measurements were performed by blinded authors (inter-rater reliability p > 0.80 for all measurements). Data were analyzed with a repeated measure ANOVA with age, duration between scans, spleen injury grade, injury severity scale, and Glasgow coma scale (GSC) included to control for potential confounders.

**Results:** One hundred and thirteen cases were included in the final analysis (IR = 17, Obs = 96) with a mean duration of 548 days between scans for all cases. While we failed to demonstrate significant results for our main hypothesis, we demonstrate that there is a significant interaction (p = 0.002) involving splenic index, which decreases after IR by -8% but increases after Obs by +20%.

**Conclusions:** While our study failed to demonstrate an interaction of splenic index relative to risk of infection, we demonstrate that splenic artery embolization alters the healing response compared to observational management.

**4:12 PM Abstract No. 21**

Splenic artery embolization after trauma: does severity of splenic index, type of embolic agent used, or location of embolization affect outcomes?

K. Singh1, A. Batouli2, D. Buck3; 1Allegheny General Hospital, Pittsburgh, PA; 2Allegheny Health Network, Pittsburgh, PA; 3University of California San Francisco, San Francisco, CA

**Purpose:** Splenic artery embolization is a common procedure performed in the setting of significant splenic trauma. The purpose of this study was to determine whether degree of splenic injury, type of embolic agent used, or location of arterial embolization affected outcomes in patients undergoing splenic artery embolization.

**Materials:** A retrospective study was performed of patients with blunt splenic trauma who underwent splenic angiography between March 2014 and September 2017. Splenic injury was graded using the American Association for the Surgery of Trauma classification. Angiographic data regarding diagnostic findings, technical success, type(s) of embolic agent used and location of embolization were recorded. The electronic medical record was reviewed to determine demographics, clinical success and procedure complications. Clinical success was defined by resolution of bleeding after embolization and avoidance of splenectomy.

**Results:** Eighty-six splenectomy patients with AAST grading (G), represented by number of complications/total cases (complication rate): G3 1/35 (3%); G4 1/25 (4%); G5 2/26 (8%). 31 SAEs with a combination of Gelfoam, microcoils, and calibrated microspheres were performed on 30 patients: G3 0/13 (0%); G4 3/14 (21%); G5 2/3 (67%). Major complications occurred in 1/19 distal SAEs (5%), a single case with persistent bleeding after SAE requiring splenectomy, and in 4/12 proximal SAEs (33%), including 3 patients with persistent bleeding after SAE requiring splenectomy and one patient with abscess formation. All SAE complications were seen with G4 and G5 injuries only. A Chi-squared analysis shows statistical significance in major complications for G5 injuries comparing SAE versus splenectomy (p = 0.005), and major complications between distal versus proximal SAE (p = 0.033).

**Conclusions:** SAE is safe and effective as observed in previous literature, although with higher major complications observed in proximal embolization and in Grade 4 and 5 lesions compared to surgical management. Complications seen with the angiographic therapy of high grade lesions suggest that initial surgical management may be better in G5 injuries. Therefore, a multidisciplinary approach to BSI is paramount.

**4:21 PM Abstract No. 22**

Splenic artery embolization for the treatment of gastric variceal bleeding secondary to splenic vein thrombosis

A. Cortes1, J. Kim2, C. Commander1, K. Devulapalli3, U. Nag4, K. Kim1; 1University of North Carolina, Chapel Hill, NC; 2UNC School of Medicine, Chapel Hill, NC; 3University of California San Francisco, San Francisco, CA; 4Duke University, Durham, NC

**Purpose:** We retrospectively reviewed all splenic injuries at our institution from 2005 to 2010. Cases were excluded if age 30 days, and absence of a follow-up CT performed for any reason that did not include the entire spleen. A priori variable of interest included splenic index at the time of injury and on follow-up imaging, calculated as the product of the largest X, Y, and Z dimensions of the spleen. Measurements were performed by blinded authors (inter-rater reliability p > 0.80 for all measurements). Data were analyzed with a repeated measure ANOVA with age, duration between scans, spleen injury grade, injury severity scale, and Glasgow coma scale (GSC) included to control for potential confounders.

**Results:** One hundred and thirteen cases were included in the final analysis (IR = 17, Obs = 96) with a mean duration of 548 days between scans for all cases. While we failed to demonstrate significant results for our main hypothesis, we demonstrate that there is a significant interaction (p = 0.002) involving splenic index, which decreases after IR by -8% but increases after Obs by +20%.

**Conclusions:** While our study failed to demonstrate an interaction of splenic index relative to risk of infection, we demonstrate that splenic artery embolization alters the healing response compared to observational management.
**Purpose:** The purpose of this study is to assess the viability of splenic artery embolization for the treatment of gastric variceal bleeding. There is a significant mortality associated with gastric variceal bleeding and not infrequently this type of bleeding is refractory or recurrent after basic resuscitative and endoscopic techniques. The varied etiologies responsible for the development of splenic vein thrombosis as well as the frequent complexity of the patient population afflicted may deem surgical interventions high risk. This highlights the integral role that splenic artery embolization serves as a means to effectively treat this entity.

**Materials:** A retrospective study of splenic artery embolization performed specifically for gastric variceal bleeding secondary to splenic vein thrombosis in 17 patients over a time period of 15 years was undertaken. Pre- and post-splenic artery embolization data were interrogated via chart reviews. Data included: patient demographics, etiologies of splenic vein thrombosis, clinical manifestations, embolic agents, complications (rebleeding, splenic infarcts, infections), and subsequent interventions (nominal medical therapies, percutaneous interventions, repeat embolization, surgical interventions).

**Results:** Three patients experienced a complication necessitating follow-up intervention, only one of which was for rebleeding. The most common etiology of splenic vein thrombosis was portal hypertension followed by pancreatic pathology. The most common clinical manifestation was upper GI bleed: hematemesis or melena. 76% of gastric varices were diagnosed and initially treated via upper endoscopy. The most common complication was splenic infarcts which were observed without clinical consequence in respective afflicted patients. No patients developed an infection.

**Conclusions:** Splenic artery embolization for gastric variceal bleeding secondary to splenic vein thrombosis is technically feasible, safe and effective. The experience at this single institution provides physicians with an evidence base to offer patients this potentially life-preserving therapy. Future studies with larger cohorts will add even more credence to this claim.

**Purpose:** The purpose of this study is to assess the viability of splenic artery embolization for the treatment of gastric variceal bleeding. There is a significant mortality associated with gastric variceal bleeding and not infrequently this type of bleeding is refractory or recurrent after basic resuscitative and endoscopic techniques. The varied etiologies responsible for the development of splenic vein thrombosis as well as the frequent complexity of the patient population afflicted may deem surgical interventions high risk. This highlights the integral role that splenic artery embolization serves as a means to effectively treat this entity.

**Materials:** A retrospective study of splenic artery embolization performed specifically for gastric variceal bleeding secondary to splenic vein thrombosis in 17 patients over a time period of 15 years was undertaken. Pre- and post-splenic artery embolization data were interrogated via chart reviews. Data included: patient demographics, etiologies of splenic vein thrombosis, clinical manifestations, embolic agents, complications (rebleeding, splenic infarcts, infections), and subsequent interventions (nominal medical therapies, percutaneous interventions, repeat embolization, surgical interventions).

**Results:** Three patients experienced a complication necessitating follow-up intervention, only one of which was for rebleeding. The most common etiology of splenic vein thrombosis was portal hypertension followed by pancreatic pathology. The most common clinical manifestation was upper GI bleed: hematemesis or melena. 76% of gastric varices were diagnosed and initially treated via upper endoscopy. The most common complication was splenic infarcts which were observed without clinical consequence in respective afflicted patients. No patients developed an infection.

**Conclusions:** Splenic artery embolization for gastric variceal bleeding secondary to splenic vein thrombosis is technically feasible, safe and effective. The experience at this single institution provides physicians with an evidence base to offer patients this potentially life-preserving therapy. Future studies with larger cohorts will add even more credence to this claim.

**Purpose:** To investigate predictive value of CT angiography (CTA) compared to RBC scintigraphy prior to transcatheter visceral angiography (TVA) in the management of lower gastrointestinal bleeding (LGIB) while considering potential nephrotoxic effects of contrast used in CTA.

**Materials:** From 11/2012 to 8/2017, 223 TVAs were performed for LGIB in patients with pre-procedural CTA and/or RBC scintigraphy. Positive predictive values (PPVs) and sensitivities were calculated for CTA and RBC scintigraphy using TVA as a reference standard. Further analysis compared PPVs of the two modalities when used in certain clinical variants of LGIB defined by ACR Appropriateness Criteria. Total contrast was compared to maximum increase of creatinine to determine if additional contrast administered with CTA resulted in increased nephrotoxicity.
Results: Prior to TVA, 38 patients underwent CTA, 173 patients underwent RBC scintigraphy, and 12 completed both. Overall, CTA had a PPV of 67.7% (95% CI: 57.0, 76.7) and sensitivity of 85.2% (66.3, 95.8) while RBC scintigraphy had a PPV of 29.3% (27.7, 31.0) and sensitivity of 94.4% (84.6, 98.8). CTA had a higher PPV across all clinical presentations of LGIB with significance demonstrated in hemodynamically stable LGIB as well as unstable LGIB. No dose-toxicity relationship was seen between CTA and interventional creatinine was 3.7 ± 3.2 mg/dL (p = 0.05). Of the patients that received iodinated contrast (n = 5), one patient had transient acute kidney injury which returned to baseline within 48 hours of the procedure. All interventional procedures were carried out successfully without adverse events associated to either the FE-MRA or interventional procedures. The mean time from the FE-MRA to the interventional procedure was 2.1 ± 2.5 days in patients receiving central venous line placement (n = 7) and 9.8 ± 5.2 days in all other cases (n = 5). The central catheter placement procedures (n = 7) required no iodinated contrast.

Conclusions: CTA has greater predictive value than RBC scintigraphy for assessing LGIB prior to TVA in various clinical scenarios. The additional contrast associated with CTA is not associated with increased nephrotoxicity.

<table>
<thead>
<tr>
<th></th>
<th>CTA PPV (95% CI)</th>
<th>Scintigraphy PPV (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>67.7 (57.0-76.7)</td>
<td>29.3 (27.7-31.0)</td>
</tr>
<tr>
<td>ACR Variant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (Stable LGIB)</td>
<td>72.2 (61.9-80.6)</td>
<td>35.7 (35.7-35.7)</td>
</tr>
<tr>
<td>2 (Unstable LGIB)</td>
<td>75.0 (52.7-89.0)</td>
<td>37.5 (33.7-41.4)</td>
</tr>
<tr>
<td>4 (Obscure LGIB)</td>
<td>25.0 (13.0-42.6)</td>
<td>17.3 (14.4-20.7)</td>
</tr>
<tr>
<td>Time to TVA &lt;4 hours</td>
<td>83.3 (83.3-83.3)</td>
<td>34.2 (33.4-35.1)</td>
</tr>
</tbody>
</table>

3:18 PM Abstract No. 25

Ferumoxytol-enhanced magnetic resonance angiography for preprocedural vascular planning in patients with chronic kidney disease
P. Shahrouki1, J. Moriarty1, S. Kee1, W. Quinones-Baldrich1, B. DeRubertis1, T. Yoshida1, P. Finn1; 1Ronald Reagan UCLA Medical Center, Los Angeles, CA

Purpose: To assess the clinical utility and safety of preprocedural vascular planning with ferumoxytol-enhanced magnetic resonance angiography (FE-MRA) in adult patients with chronic kidney disease (CKD).

Materials: Patients with CKD undergoing preprocedural FE-MRA and subsequently undergoing thoracoabdominopelvic vascular interventional procedures were retrospectively included in the study. Patients undergoing preprocedural FE-MRA for aortic stenosis were not included as this has already been described elsewhere. Retrospective chart review was conducted to determine clinical impact of FE-MRA with respect to details of interventional procedure, renal function and adverse events.

Results: Between March 2014 and August 2017, twelve consecutive patients with CKD who underwent FE-MRA prior to an interventional vascular procedure were retrospectively identified. The primary imaging indications were venous mapping prior to central line placement (n = 7), venous recanalization or thrombolysis (n = 2), aortic (n = 2) or iliac artery aneurysm repair (n = 1). The FE-MRA provided interventionists with confident assessment of venous patency, dimensions of aneurysm and characteristics of access vessels prior to procedures. Neither of the cases required additional imaging prior to intervention. The mean pre-interventional creatinine was 4.1 ± 3.5 mg/dL, and the mean post-interventional creatinine was 3.7 ± 3.2 mg/dL (p = 0.05). Of the patients that received iodinated contrast (n = 5), one patient had transient acute kidney injury which returned to baseline within 48 hours of the procedure. All interventional procedures were carried out successfully without adverse events associated to either the FE-MRA or interventional procedures. The mean time from the FE-MRA to the interventional procedure was 2.1 ± 2.5 days in patients receiving central venous line placement (n = 7) and 9.8 ± 5.2 days in all other cases (n = 5). The central catheter placement procedures (n = 7) required no iodinated contrast.

Conclusions: FE-MRA is a powerful and safe imaging tool that gives interventionists efficient and confident preprocedural vascular assessment prior to procedures.
Additional analysis found that for every year increase between images analyzed, ML sac dimension increased by 0.2 mm (SE = 0.097, p = 0.037).

**Conclusions:** Untreated PAVM feeders grew very slowly if at all in the near-decade span of this study, and any demonstrated growth was minimal. These findings challenge the current recommendation of 3- to 5-year CT follow-up.

**3:36 PM**  
**Abstract No. 27**

**A comparison of prostate computed tomography angiogram protocols for visualization of prostate arteries prior to prostate artery embolization**  
A. Hall1, K. Pereira2, S. Gadani3, L. Aryan4, A. Sherwani2, R. Bant2, J. Guynan2, T. Gebke5, J. Almeyer6, A. Fang2, L. Morel-Ovalle2, J. Kao2, K. Vaheesan5, 1Saint Louis University, Biomedical Engineering, St. Louis, MO; 2Saint Louis University, Vascular & Interventional Radiology, St. Louis, MO; 3Saint Louis University, Vascular & Interventional Radiology, St. Louis, MO; 4Saint Louis University Biomedical Engineering, St. Louis, MO; 5Saint Louis University, St. Louis, MO; 6Saint Louis University Hospital, St. Louis, MO; 7St. Louis University Hospital, Ellisville, MO; 8St. Louis University, St. Louis, MO

**Purpose:** Computed tomography angiography (CTA) can be useful for identification of the prostate arteries (PA) prior to PAE for benign prostatic hyperplasia (BPH). This enables identification of the number, navigation path, tortuosity, and dominance of the PA's, as well as planning optimal C-arm angles for navigation. However, the small size of the arteries (0.5-2 mm) makes CTA imaging a challenge.

**Materials:** An IRB waiver was obtained. Twenty anonymized CTA scans were examined by three physicians; ten patients were scanned with a contrast injection rate of 5cc/sec (100 cc total), and ten who were scanned with an injection rate of 6 cc/sec (100 or 150 cc total), and who also received two 5 mg tabs of sublingual nitroglycerine, 5 min apart. All patients were scanned on a Siemens Definition Flash (Erlangen, Germany). Tube potential was 100kV. Scan delay was 10 sec, and bolus tracking was used (+120HU with ROI at aortic bifurcation). Images were reconstructed at 0.6 mm or 1.0 mm slice thickness. The origin and course of each PA leading to the aortic bifurcation (ROI at aortic bifurcation). Images were reconstructed at 0.6 mm or 1.0 mm slice thickness. The origin and course of each PA leading to the prostate was examined. Images were rated as: visualized with high confidence (2), visualized with low confidence (1), and not visualized (0).

**Results:** The ages and weights of the patient groups were not significantly different (P = 0.202 and 0.177, respectively, t-test). The average HU values measured at the aortic bifurcation were 283 for the 5 cc/sec group and 511 for the 6 cc/sec group (P < 0.0001, t-test). Average visualization ratings for the PA origin were 1.00 for the 5cc/sec group and 1.72 for the 6cc/sec group. Average visualization ratings for the PA course were 0.98 for the 5cc/sec group and 1.78 for the 6cc/sec group. The differences were found to be statistically significant (P < 0.0001, Mann-Whitney test).

**Conclusions:** An optimized CTA protocol using a higher rate of injection of 6 mm/cc, and adding sublingual nitroglycerin, yields significantly better visualization of the PA origin and course.

**Future work** will attempt to evaluate if better preprocedural visualization of the PA translates into easier catheterization of the PA, allowing for reduced radiation, contrast, and procedure times.

**3:45 PM**  
**Abstract No. 28**

**Value of a novel automated (digital) ankle brachial index device as a screening tool for peripheral arterial disease in an outpatient clinic setting: a preliminary prospective study**

S. Wilson-Flewelling1, R. Salamo1, Y. Akpolar2, K. Pereira2, J. Kao2, K. Vaheesan5, S. Gadani6, L. Morel-Ovalle1, A. Fang7, 1Saint Louis University, St. Louis, MO; 2Saint Louis University School of Medicine, St. Louis, MO; 3Department of Interventional Radiology, St. Louis, MO; 4N/A, St. Louis, MO; 5Saint Louis University Hospital, St. Louis, MO; 6Saint Louis University Hospital, Ellisville, MO; 7St. Louis University, St. Louis, MO

**Purpose:** Peripheral arterial disease (PAD) is a continuously growing concern in the United States affecting 8-18 million Americans. Medical guidelines recognize ankle-brachial index (ABI) testing as an effective screening tool that allows for early detection of this disease. Doppler ABI, the standard method used, is time consuming, requires technical expertise and is usually performed in a dedicated vascular lab. Automated (digital) ABI (d-ABI) using plethysmography is novel and may be a more attractive method in primary care settings due to its speed and ease of use; however, there is scarcity of evidence of the use of this device in medical literature. The purpose of this study was to assess the ease of implementation of the d-ABI i and to assess the positive predictive value.

**Materials:** This prospective clinical trial (ClinicalTrials.gov NCT03161327) was approved by local IRB and conducted over a period of 6 weeks. All patients at four outpatient clinics (Endocrine, Geriatrics, Hepatology and Internal medicine), at an academic University Hospital received a standardized PAD questionnaire. Inclusion criteria was based of the American Heart Association PAD guidelines; those that met the criteria received the QuantaFlow Digital ABI exam (Semler Scientific Inc.).

**Results:** ABI’s were performed during the course of the routine clinic visit (unrelated to PAD) to the physician. Average time to perform the test was about 3 to 4 minutes; more importantly addition of this test did not impede overall clinic efficiency. A total of 1791 patients were given screening questionnaires, of which 243 (13.8%) met inclusion criteria for PAD screening and agreed to participate in the study. Of these, 44 patients were found to have positive ABIs: 10 had severe reduction in ABI (50% stenosis on imaging was 67%), and that for 0.41-0.9 was 14%.

**Conclusions:** Given the high number of patients that met inclusion criteria, addition of d-ABI screening for PAD appears to be useful and convenient in an outpatient setting. Our results so far have yielded suboptimal positive predictive values with this device. However, a larger case study may be needed to validate automated (digital) ABI as an effective screening tool for detection of PAD.
Augmented reality guidance for cerebral angiography

G. Loeb¹, S. Sadri¹, A. Grinshpoon¹, J. Carroll², C. Cooper², C. Elvezio³, S. Mutasa⁴, G. Mandigo⁵, S. Lavine⁶, J. Weintraub⁷, A. Einstein⁸, S. Feiner¹, P. Meyers⁹; ¹Columbia University, New York, NY; ²Columbia University/New York Presbyterian Hospital, New York, NY

Purpose: Augmented reality (AR) holds great potential for IR by integrating virtual 3D anatomic models into the real world. In this pilot study, we developed an AR guidance system for cerebral angiography, evaluated its impact on radiation, contrast, and fluoroscopy time, and assessed physician response.

Materials: In this prospective study, 9 patients with CT or MR imaging underwent diagnostic neuroangiography with AR guidance from June to August 2017. Before each procedure, segmentation software was used to create a 3D model of the patient’s aortic arch including carotid and vertebral arteries. The model was deployed to HoloLens (Microsoft, Redmond, WA), a stereoscopic optical see-through AR head-worn display. Using the AR user interface we developed, physicians manipulated a virtual 3D model intraoperatively via voice commands, gaze, and gestures while maintaining sterility. In total, 6 physicians completed 14 postoperative questionnaires assessing the system. 18 case-matched retrospective controls were identified by screening for age, aorta imaging, cone-beam CT, indication, physician, and OR.

Results: All 9 patients underwent diagnostic neuroangiography per standard protocol with AR guidance without complication. Mean kerma-area product 3150 μGy•m² (SD 2284), skin-absorbed dose 283 mGy (SD 192), contrast volume 119 mL (SD 35), and fluoroscopy time 10 min (SD 4) were below reference values for diagnostic neuroangiography. There was a non-significant reduction in kerma-area product, skin-absorbed dose, and fluoroscopy time compared to case-matched controls. 100% of questionnaire responses indicated physicians would recommend the AR system and felt it neither interfered with safety nor increased radiation, contrast, or procedure time. 79% indicated it helped them navigate through vasculature. 93% indicated it was useful to see the 3D model in AR.

Conclusions: AR guidance for neuroangiography produced clinical outcomes, fluoroscopy times, and radiation doses comparable to those of conventional neuroangiography in matched controls. Results suggest that this technology is feasible and safe to use intraoperatively, offering an opportunity to enhance navigation through patient anatomy.

Augmented virtual reality assisted treatment planning for splenic artery aneurysms: a pilot study

Z. Devcic¹, I. Idakoji¹, A. Kesselman¹, R. Shah¹, M. AbdelRazeq¹, N. Kothary¹; ¹Stanford University Medical Center, Stanford, CA

Purpose: To evaluate the utility of augmented virtual reality (VR) in preprocedural planning for endovascular repair of splenic artery aneurysms (SAA) as compared to standard volume-rendering (SR) software.

Materials: Preprocedural computed tomographic angiography (CTA) images of 14 patients with 17 SAAs who had undergone endovascular repair were reconstructed using True 3D (EchoPixel, Inc., CA), a VR visualization software system. AquariusNet (TeraRecon, CA) was used for standard volume-rendering image interpretation. Three radiologists independently evaluated the number of inflow and outflow arteries associated with the SAA and subjectively by operator confidence.

Results: There were 17 inflow and 22 outflow arteries associated with the SAA. The overall sensitivity, accuracy and positive predictive value for VR was similar to that of SR (91.3%, 89.7%, 84% and 88.9%, 88.9%, 84.6%, p = 0.14, respectively). However, the ability to view and manipulate images in true three-dimensions using VR markedly improved operator confidence with 93% receiving a score of at least 3 (71% = 3, 21% = 4).

Conclusions: SAA have complex anatomy necessitating meticulous preprocedure planning. VR allows holographic visualization of images as if they were real physical objects, providing information critical for endovascular repair of SAA and thus significantly increasing operator confidence.

Efficacy of the preoperative planning for TEVAR using the greater curvature measurement with virtual stentgraft image

S. Iwakoshiⁱ, S. Ichihashi², S. Sakaguchi², K. Kichikawa³; ¹Nara Medical University, Kashihara City, Japan; ²Nara Medical University, Nara, Kashihara, Japan; ³Nara Medical University, Kashihara, Nara, Japan

Purpose: To assess the accuracy of preoperative planning for TEVAR using the greater curvature measurement with virtual stentgraft image.

Materials: From January 2012 to December 2016, patients treated at our institution were retrospectively analyzed. Patients who were treated with more than two devices, treated for aortic dissection, and did not have proper preoperative and postoperative CT data were excluded. From the preoperative CT data, the virtual stentgraft images based on the center lumen line (CL) measurement, the greater curvature (GC) measurement and the smaller curvature (SC) measurement were created using SYNAPSE VINCENT software. These virtual stentgraft images were superimposed on the postoperative CT to measure the misalignment between these virtual stentgraft images and the actual stentgraft position. A statistical comparison using Wilcoxon’s signed rank sum test was performed. In addition, the actual stentgraft lengths were measured based on CL from postoperative CT data and compared to its original length.

Results: A total of 35 cases were analyzed. Twenty-six were men. The average age of the patients was 72.4 ± 13.0 years. Aneurysms were located at the descending aorta (n = 11), and the aortic arch (n = 24). The gap between the virtual stentgraft based on SC, CL,
GC and the actual stentgraft position were - 47.8 ± 18.1 mm, - 21.5 ± 9.4 mm and 5.3 ± 7.4 mm, respectively. These differences were all statistically significant (p<0.001). The relationship between the actual stentgraft length (AL) based on CL and its original length (OL) was represented by the math formula described as follows, AL = OL * 0.92 – 0.05 (in descending cases) and AL = OL * 0.77 + 9.85 (in aortic arch cases).

Conclusions: The preoperative planning using the greater curvature measurement with virtual stentgraft image was extremely accurate.

Quantitation of hepatic fibrosis by ultrasound in diethylnitrosamine-induced rat model of hepatocellular carcinoma


Purpose: The toxin diethylnitrosamine (DEN) causes stepwise progression of the hepatic inflammation-fibrosis-cancer (IFC) axis in the liver, providing for a rat model of hepatocellular carcinoma (HCC). This study aims to quantitate these liver changes using computer extracted grayscale ultrasound features in this DEN rat model of HCC.

Materials: Fibrosis was induced in 7 male Wistar rats via ingestion of 0.01% DEN in drinking water for 12 weeks. Rats were imaged with ultrasound (US) at three-time points: baseline, 10 weeks, and 13 weeks. For each rat, 4-6 grayscale images were acquired from different lobes of the liver in standard imaging planes. US settings, including gain and time gain compensation, were kept constant for each imaging session. Images were analyzed quantitatively to measure echo-intensity level and 1st order histogram variance value (homogeneity level). Two-sample student t-test was used for comparison of data at the three-time points. Necropsy was performed after natural death or euthanasia. A sample of non-tumorous liver from 6 animals was sectioned and stained with hematoxylin-eosin and trichrome stains. Fibrosis was assessed using the METAVIR scoring system. Histology was correlated with final time-point imaging.

Results: Liver echo-intensity level across all rats showed an average increase from 42.9 at baseline to 56.4 at 10 weeks (p = 0.0013), reaching the level of 59.9 at 13 weeks (p = 0.0002) from DEN induction. Liver tissue homogeneity level (variance) showed an increase from 270 at baseline to 526 at 10 weeks (p = 0.0002) and 477 at the final time point (p = 0.0015). These changes corresponded to fibrotic changes on histology. The highest final echo-intensity level observed (67.1) corresponded with histology METAVIR grade F4, cirrhosis. The lowest final echo-intensity level recorded (54.3) corresponded with METAVIR grade F2, moderate fibrosis.

Conclusions: Liver echo-intensity increased as time progressed in the inflammation-fibrosis-cancer cascade. Higher final intensities corresponded to greater fibrosis on histology. This quantitative radiologic correlation of liver fibrosis will be useful to evaluate background fibrotic changes accompanying rat HCC growth in future experiments.

Chemoembolization: Liver 1

Sunday, March 18, 2018
3:00 PM–4:30 PM
Room: 405

Pre-TACE immune status correlates with treatment response and necrosis rates in HCC as a bridge to liver transplant


Purpose: Immune factors play a key role against disease progression in hepatocellular carcinoma (HCC). With chemoembolization (DEB-TACE) as a bridge to liver transplant, this study compares pretreatment immune function to DEB-TACE response and tumor explant pathology.

Materials: A retrospective analysis was performed on all patients who were treated for HCC with DEB-TACE (100-300 μm LC Beads™ mixed with doxorubicin) from 7/2011 to 5/2016 and subsequently transplanted (n = 93). Serum analysis was performed on the morning of DEB-TACE. Treatment response was based on modified RECIST criteria. Additional treatments were performed as deemed necessary, based on incomplete treatment response. Pretreatment laboratory markers were compared with posttreatment imaging response and sustained treatment response prior to transplant as well as tumor biology and necrosis rates at explant.

Results: Pretreatment absolute lymphocyte counts (ALC) were lower in patients with stable disease (SD) at initial follow-up compared to patients with complete response (CR) or partial response (PR), 1.09 in SD vs 1.43 in CR/PR, p = 0.02. Fifty-two patients were lymphopenic (ALC < 1.2) prior to initial DEB-TACE and 41 patients were lymphocompetent (ALC > 1.2). ALC was associated with pretreatment Child-Pugh score (p = 0.003) and albumin level (p = 0.04). Lymphopenia also correlated with poor long-term responses to DEB-TACE, found in 100% (4/4) with disease progression and 85% (11/13) SD prior to transplant (p = 0.01). Additionally, lymphopenic patients had lower target lesion necrosis at liver explant (p = 0.04). Complete necrosis was identified in 44% of lymphocompetent patients vs 16% of lymphopenic patients (p = 0.003).

Conclusions: Unfavorable DEB-TACE treatment response was associated with low lymphocyte counts, a marker for immunosurveillance, suggesting a role in posttreatment tumor activity. Noting an association between ALC and Child-Pugh score as well as albumin, cirrhosis severity may play a role in immune activity.
Neutrophil to lymphocyte ratio (NLR) predicts early tumor progression in transarterial chemoembolization (TACE) for hepatocellular carcinoma (HCC): assessment by mRECIST

J. Watchmaker1, J. Cruz2, M. Albin2, M. Fritsche2, J. Su3, J. Fleming3, S. Alexopoulos2, S. Geervarghese3, J. Baker2, T. Borgmann3, F. Banovac2, D. Brown2; 1Vanderbilt University, Nashville, TN; 2Vanderbilt University Medical Center, Nashville, TN; 3Vanderbilt School of Medicine, Nashville, TN

Purpose: Pilot studies identified a potential association between elevated NLR and early tumor progression following intra-arterial therapy. The purpose of our study is to further evaluate if elevated preprocedural NLR predicts progressive disease following TACE.

Materials: With IRB approval, we reviewed TACE procedures in HCC patients between 7/2013 – 7/2017. Treatment was conventional TACE (cTACE) or drug-eluting bead (DEB)-TACE. Child-Pugh score, etiology of cirrhosis, tumor number, diameter of largest two tumors and presence of portal vein thrombosis (PVT) was tracked. Complete blood count with differential was obtained prior to the procedure for NLR calculation. Follow-up imaging was performed 2 months post-treatment. Response was assessed with mRECIST. The primary objective was to determine the effect of abnormally elevated preprocedural NLR (≥ 3.5) on tumor response using Chi-squared analysis. A p < 0.05 was required for significance.

Results: 197 patients underwent a total of 253 procedures: 170 cTACE and 83 DEB-TACE. 149 patients were male; 48 were female. Mean patient age was 62. Child Pugh Scores were 132 A, 61 B, and 4 C. Cirrhosis etiology was alcohol in 50 (25%), hepatitis C in 107 (54%), hepatitis B in 14 (7%), and non-alcoholic fatty liver disease in 42 (21%) patients. 128 patients had single (65%), 42 (21%) had 2 and 27 (14%) had 3 foci of HCC. Mean tumor diameter was 4.58 cm. 13 patients had PVT. 194 (76.6%) patients had a preprocedural NLR ≥ 3.5, and 59 (23%) patients had a preprocedural NLR ≥ 3.5. Patients that had progressive disease following TACE had a significantly higher preprocedural NLR (mean = 4.10) compared to patients with complete response (mean NLR = 2.48); partial response (mean NLR = 2.72) and stable disease (mean NLR = 2.76); Odds-ratio 2.1, p = 0.04.

Conclusions: Elevated preprocedural NLR may be a useful predictor of poor treatment outcome in patients with HCC undergoing TACE. Short interval follow-up in this group may be valuable to improve outcomes.

<table>
<thead>
<tr>
<th></th>
<th>Complete Response</th>
<th>Partial Response</th>
<th>Stable Disease</th>
<th>Progressive Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>n, %</td>
<td>78 (30%)</td>
<td>97 (38%)</td>
<td>40 (16%)</td>
<td>39 (16%)</td>
</tr>
<tr>
<td>NLR ≥3.5, n (%)</td>
<td>12 (15%)</td>
<td>19 (20%)</td>
<td>14 (35%)</td>
<td>14 (36%)</td>
</tr>
<tr>
<td>NLR Mean</td>
<td>2.48</td>
<td>2.72</td>
<td>2.76</td>
<td>4.10</td>
</tr>
<tr>
<td>cTACE/DEB-TACE</td>
<td>52/26</td>
<td>71/26</td>
<td>22/18</td>
<td>25/14</td>
</tr>
</tbody>
</table>

Lymphopenia selects poor DEB-TACE response in transplant waitlist patients: prospective, single-center, observational study

T. Sandow1, P. Thevenot2, J. Gimenez2, S. Arndt2, K. Nunez2, D. DeVun2, P. Gulotta2, V. Ramalingam2, P. Gilbert2, D. Kirsch2, H. Bohorquez2, D. Kay2, A. Cohen2; 1Georgetown University Hospital, Washington, DC; 2Ochsner Clinic Foundation, New Orleans, LA

Purpose: DEB-TACE has demonstrated efficacy in downstaging or bridging patients with hepatocellular carcinoma (HCC) to transplant, yet variable treatment responses are seen among equivocal tumors. Using immune markers, the study seeks to identify immediate and sustained HCC treatment response to DEB-TACE.

Materials: A single-center, prospective analysis was performed on patients who were treated for HCC with DEB-TACE (100-300 μm LC Beads™ mixed with 50 mg of doxorubicin). To date, 54 consecutive patients have been enrolled. Serum blood samples were obtained immediately prior to treatment as well as 6 weeks and 3 months postprocedure. Posttreatment imaging was obtained 1 month after DEB-TACE as well as routine quarterly intervals. Treatment response was based on modified RECIST imaging criteria. Repeat treatments were performed as deemed necessary, based on incomplete treatment response.

Results: Logistic regression analysis demonstrated absolute lymphocyte count (ALC) as the strongest predictor for objective response (p = 0.015). Prior to treatment, 24 patients were identified as lymphopenic (ALC <1.2), and 30 patients were lymphocompetent (ALC ≥1.2). Patients with normal ALC values demonstrated an objective treatment response of 81% vs 51% in patients with lymphopenia (p = 0.02). Similarly, complete response was identified in 54% of patients with normal ALC vs 39% of patients with lymphopenia, while disease progression was seen in 12% of patients with normal ALC vs 24% of patients with lymphopenia. The ratio of T-cell lineages (CD4:CD8 ratio) showed a strong association with mRECIST (p = 0.03), and CD4:CD8 ratio also inversely correlated with ALC (R = -0.356, p = 0.05). Lymphopenic patients showed dramatic expansion of myeloid derived suppressor cells (MDSCs) (p = 0.002), which remained increased at posttreatment follow-up. Eleven patients in the cohort were transplanted. 5 were lymphopenic before DEB-TACE and all had viable lesions at explant compared to 1 out of 6 lymphocompetent patients.

Conclusions: Lymphopenia and lineage imbalance may provide a strong predictor of DEB-TACE outcome by identifying patient immunotolerance with impaired antitumor immunity against residual HCC following DEB-TACE.
Comparison of pathologic treatment response between conventional and doxorubicin-eluting bead chemoembolization in explanted livers

D. Fung1, S. Kim1, R. Ramaswamy1, A. Salter1, N. Mani1, O. Akinwande1; 1Washington University School of Medicine, St. Louis, MO

Purpose: To compare pathologic treatment response between conventional (cTACE) and doxorubicin-eluting bead chemoembolization (DEB-TACE) in explanted livers.

Materials: A retrospective review was performed of all patients who received treatment with either cTACE or DEB-TACE that subsequently had a liver transplant from June 2009 to June 2016. A total of 200 unique patients were identified. 128 patients met inclusion criteria of having hepatocellular carcinoma (HCC) on pathology, quantitative tumor viability pathology reports, and only having one type of TACE (cTACE (n = 95) and DEB-TACE (n = 33)) before explant. Only treated tumors were included. Time interval between last TACE and liver transplant was a mean of 134 days (range, 1 - 496 days). Student t-test was used to compare means and chi square test was used to compare categorical variables.

Results: 173 tumors were identified in these 128 patients, with 124 tumors in the cTACE group and 49 tumors in the DEB-TACE group. Tumor grade was similar in both groups. Average number of treatments were 1.62 (SD: 0.82) in the cTACE group and 1.47 (SD: 0.66) in the DEB-TACE group. Categories of pathologic tumor response were 0%, 50%, 100% viability. 0% viability was seen in 32/124 (25.8%) tumors in the cTACE group and 10/49 (20.4%) tumors in the DEB-TACE group. 50% viability was seen in 48/124 (38.7%) tumors in the cTACE group and 23/49 (46.9%) in the DEB-TACE group. 100% viability was seen in 33/124 (26.6%) in the cTACE group and 14/49 (28.6%) in the DEB-TACE group. The mean tumor viability after cTACE and DEB-TACE treatments were 41.8% and 38.7% respectively. The pathologic treatment response between both groups did not approach statistical significance (p = 0.50).

Conclusions: In this study, no difference in pathologic treatment response was seen in HCC treated with cTACE and DEB-TACE. Either cTACE or DEB-TACE can be an acceptable treatment to achieve tumor control for patients awaiting liver transplant.

Stratification and prognosis for portal vein invaded hepatocellular carcinoma treated with transarterial chemoembolization monotherapy

B. Zhong1, C. Ni2, S. Chen2, G. Teng1; 1Zhongda Hospital, Southeast University, Nanjing, China; 2First Affiliated Hospital of Soochow University, Suzhou, China; 3Cancer Hospital of Jiangsu Province, Cancer Institution of Jiangsu Province, Nanjing, China

Purpose: Due to patient heterogeneity, who would benefit from transarterial chemoembolization (TACE) monotherapy for portal vein invaded hepatocellular carcinoma (HCC) is still uncertain. We aim to establish a prediction model to determine and select the beneficial patients.

Materials: HCC patients with portal vein invasion and treated with TACE monotherapy at three hospitals between January 2008 and December 2016 were included. In the training cohort, independent risk factors associated with overall survival (OS) were identified by univariate and multivariate Cox proportional hazards analyses. Then, a prognostic model was established to find out who will benefit most from TACE monotherapy. The accuracy of the model was validated externally in the validation cohort.

Results: A total of 180 patients (training cohort: n = 126; validation cohort: n = 54) were included. In the training cohort, the median OS was 6.4 months. The prognostic prediction (PP) model was established based on the following three independent risk factors: Cheng’s classification (0 if type I, 1.5 if type II, 11 if type III), number of HCC nodules (0 if 1, 6.5 if >1), and Child-Pugh stage (0 if A, 5.5 if B7). PP score of 9.5 was identified as cut-off point and patients were divided into two groups by PP score of <9.5 and >9.5 in survival benefit and prognostication (8.5 vs. 4.2

Retrospective analysis of 30-60μm and 50-100μm HepaSphere drug-eluting beads doxorubicin (DEBDOX) embolization in BCLC B patients with non-resectable hepatocellular carcinoma: preliminary results

B. Maher1, D. Klass1, F. Chou1, D. Liu1, H. Walton1, J. Chung1; 1University of British Columbia, Vancouver, BC

Purpose: There remains a paucity of evidence regarding the most efficacious bead size to use in drug-eluting bead transarterial chemoembolization. We sought to compare matched groups of non-resectable BCLC B patients with HCC undergoing DEBDOX using either 30-60μm or 50-100μm HepaSphere Microspheres (Merit Medical) as the delivery system.

Materials: Retrospective analysis of patients undergoing DEBDOX administration in non-resectable multicentric disease. All patients underwent a DEBDOX protocol utilizing a sequential lobar technique, with 50-75 mg of doxorubicin loaded onto one vial of either 30-60μm HepaSpheres (group 1, N = 30) or 50-100μm HepaSpheres (group 2, N = 14). Outcome measures defined as 1-month radiographic response rate and TTP.

Results: Group 1 - M/F (%) = 87:13, Age range 54-91 years. Objective response rate (ORR) at 1 month was 83.4%, CR 46.7%, PR 36.7%, SD 10% and PD 6.6%. 43% have demonstrated no progression to date. In those demonstrating progression, TTP mean = 179 days (range, 31-422). Group 2 - M/F % = 71:29, age range = 48-87. ORR for group 2 was 57.1%, CR 21.4%, PR 35.7%, SD 0% and PD 24.9%. All patients have developed progressive disease. TTP mean = 141 days (range, 30-458). Statistical difference was demonstrated between the groups: Mann-Whitney U = 142.5 and P = 0.04551.

Conclusions: Our single-center experience indicates observed significant trend towards improved ORR with 30-60 μm in comparison to 50-100 μm HepaSpheres at 1 month. TTP and overall survival analysis is ongoing; however, these early results indicate that smaller particles may convey significant advantages in achieving improved outcome in effective TACE delivery.
months). The PP model received high accuracy with C-index of 0.742 when validated in the validation cohort.

Conclusions: Portal vein invaded HCC patients with PP score <9.5 may benefit most from TACE monotherapy.

3:54 PM Abstract No. 39

Comparative analysis of the efficacy of TACE for the treatment of hepatocellular carcinoma in patients with and without TIPS
M. Chiarello¹, E. Aaltonen², M. McDermott³; ¹New York University, New York, NY; ²New York University, New York, NY; ³New York University, New York, NY

Purpose: Among the limited available published data, there are conflicting results regarding the efficacy of transarterial chemoembolization (TACE) in patients with transjugular intrahepatic portosystemic shunts (TIPS). We performed a comparative analysis to determine efficacy of TACE for the treatment of hepatocellular carcinoma (HCC) in patients with TIPS in place, as compared to those patients without portosystemic shunts.

Materials: A retrospective review of all patients treated with TACE for HCC from 2008 through 2017 was performed. We identified 25 patients for which TACE was performed with a TIPS in place. Additionally, 25 control patients without a TIPS were identified, who also underwent TACE during this time period. The modified response evaluation criteria in solid tumors (mRECIST) was used to gauge response and TACE efficacy. The major endpoints evaluated were: disease progression, non-progressive disease, survival to transplant and death.

Results: The two groups had similar demographics including age and sex distribution. There was a significant difference in the pre-TACE MELD score in the TIPS group (13.2 vs 9.5; p = 0.00). Multivariate analysis demonstrated no significant difference in the change in MELD between the two groups (p = 0.079). However, on a subgroup analysis comparing cTACE vs DEB-TACE, there was a significant increase in the MELD score in the cTACE/TIPS group (p = 0.047), but not in the DEB-TACE/TIPS group (p = 1.00). No significant difference in time to liver transplant between the two groups (p = 0.772) was identified, however, there was a significantly higher death rate in the TIPS group (5/25 vs 0/25, p = 0.025).

Conclusions: Our results show that there was no overall increased risk of hepatotoxicity for TACE in patients with preexisting TIPS, however, DEB-TACE may be preferable in this patient population based on the subgroup analysis. Although there was a higher death rate in the TIPS group, this result is complicated by baseline higher MELD in the study group.

4:03 PM Abstract No. 40

Comparative analysis of the safety of TACE for the treatment of hepatocellular carcinoma in patients with and without TIPS
M. Chiarello¹, E. Aaltonen², M. McDermott³; ¹New York University, New York, NY; ²NYU, New York, NY; ³New York University, New York, NY

Purpose: Published data suggests that transarterial chemoembolization (TACE) in patients with transjugular intrahepatic portosystemic shunts (TIPS) may be less safe than in patients without. We performed a comparative analysis to determine the safety of TACE for the treatment of hepatocellular carcinoma (HCC) in patients with TIPS vs those without.

Materials: This is a retrospective review of patients treated with TACE for HCC between 2008 and 2017. We identified 25 patients for which TACE was performed with a TIPS in place. An additional 25 control patients without TIPS who also underwent TACE were identified. The MELD score was recorded before and at 3-6 months after TACE as a marker of hepatotoxicity. Sub-group analysis between conventional TACE (cTACE) and TACE with drug-eluting beads (DEB-TACE) was also performed. Major endpoints were transplantation and death.

Results: The two groups had similar demographics including age and sex distribution. There was a significant difference in the pre-TACE MELD score in the TIPS group (13.2 vs 9.5; p = 0.00). Multivariate analysis demonstrated no significant difference in the change in MELD between the two groups (p = 0.079). However, on a subgroup analysis comparing cTACE vs DEB-TACE, there was a significant increase in the MELD score in the cTACE/TIPS group (p = 0.047), but not in the DEB-TACE/TIPS group (p = 1.00). No significant difference in time to liver transplant between the two groups (p = 0.772) was identified, however, there was a significantly higher death rate in the TIPS group (5/25 vs 0/25, p = 0.025).

Conclusions: Our results show that there was no overall increased risk of hepatotoxicity for TACE in patients with preexisting TIPS, however, DEB-TACE may be preferable in this patient population based on the subgroup analysis. Although there was a higher death rate in the TIPS group, this result is complicated by baseline higher MELD in the study group.

4:12 PM Abstract No. 41

Interim analysis of pilot randomized trial of transarterial chemoembolization with or without stereotactic body radiation therapy for hepatocellular carcinoma patients awaiting liver transplantation
G. Nadolski¹, A. Kalbasi², M. Soulen³, S. Hunt³, M. Dagli⁵, J. Mondschein⁶, D. Sudheendra⁷, S. Stavropoulos⁸, S. Apisarnthanarax⁹, M. Hoteit¹, E. Ben-Josef¹; ¹University of Pennsylvania, Philadelphia, PA; ²UCLA, Los Angeles, CA; ³University of Pennsylvania, Lafayette Hill, PA; ⁴Hospital of the University of Pennsylvania, Philadelphia, PA; ⁵N/A, Philadelphia, PA; ⁶Hospital of the University of Pennsylvania, Moorestown, NJ; ⁷Hospital of the University of Pennsylvania, Philadelphia, PA; ⁸University of Pennsylvania, Bryn Mawr, PA

Purpose: Patients with hepatocellular carcinoma (HCC) listed for orthotopic liver transplantation (OLT) undergo bridging locoregional therapy (LRT) to prevent delisting. Complete tumor necrosis after LRT improves post-OLT survival outcomes. A multicenter pilot clinical trial is being conducted to obtain baseline estimates of complete necrosis rates for transarterial chemoembolization (T) alone and with the addition of stereotactic body radiation (S) to allow adequate powering of future trials.
Materials: This trial began enrolling in January 2014 with an accrual goal of 20 patients in each arm. Inclusion criteria included HCC within Milan criteria, albumin > 2.4 g/dL, total bilirubin < 2 mg/dL, and CPT score < B7. Exclusion criteria included prior LRT or OLT, ascites refractory to medical therapy, and contraindications to radiotherapy or TACE. Randomization occurred prior to TACE. TACE was performed using lipiodol emulsion with 50 mg of doxorubicin and 10 g of mitomycin C followed by 100-300 micron microspheres. SBRT was performed to deliver 40 Gy in 5 fractions with dose reduction parameters if needed.

Results: 24 patients have been randomized (12T, 12S). The median tumor number (T 1.5, S1, p = 0.6) and diameter of largest tumor (T 26 mm, S 25 mm, p = 0.7) did not differ between groups. Median number of TACEs performed was 1 in both groups with 1 subject in each group receiving a second TACE (p = 0.99). One SAE occurred in 1 S subject following TACE but prior to SBRT. No SAEs were observed as a result of combined therapy and no dose reductions in SBRT were needed. Complete mRECIST response was observed in 6 T subjects and 3 S subjects (p = 0.6). One subject in each group had radiologic progression with 1 S subject progressing outside Milan criteria (p = 0.99). 9 T and 7 S subjects were transplanted (p = 0.6) at a median of 352 and 243 days respectively (p = 0.2). On explant histology, 5 T and 3 S patients had complete necrosis of the index lesion (p = 0.99).

Conclusions: The addition of SBRT to TACE as a bridging LRT is safe. At the accrual midpoint, the addition of SBRT does not appear to improve complete imaging response or histologic necrosis rate.

Transarterial chemoembolization with 40-micron drug-eluting beads: a multicenter study, a San Antonio experience

P. Pallan1, M. Wholey2, R. Palacios3, J. Lutz2, A. Mendez Castillo3, A. Mehta3; 1Metropolitan Methodist Hospital, San Antonio, TX; 2Audie Murphy VA hospital, San Antonio, TX; 3N/A, San Antonio, TX

Purpose: A multicenter retrospective study to demonstrate the safety and effectiveness of transarterial chemoembolization (TACE) with doxorubicin delivered in 40 μM Oncozene drug-eluting beads (DEBs) in a real-world cohort of hepatocellular carcinoma (HCC) patients from 2013-2016. The use of post procedure non-contrast-enhanced CT after TACE with 40 μM Oncozene will be discussed.

Materials: The data of 49 patients in early-intermediate HCC (Barcelona Clinic Liver Cancer Stage A/B) treated with 40 μM DEBs preloaded with 75-100 mg doxorubicin, from a community hospital and veterans administration hospital from 2013-2016 was retrospectively analyzed. 14 patients received a non-contrast CT scan after each embolization in order to evaluate if target lesions had proper uptake and to evaluate for non-target embolization. Response to therapy was assessed with Response Evaluation Criteria in Solid Tumors (RECIST) and modified RECIST (mRECIST) guidelines applied to computed tomography or MRI imaging. Adverse events were reviews by according to the National Cancer Institute Common Terminology Criteria for Adverse Events, version 4.03 and hepatotoxicity was assessed according to Drug-Induced Liver Injury Network (DILIN).

Results: The 1-year survival rate was 89%, 2 years survival was 50% and for 44% for 3 years. mRECIST response was 15(24%) complete response, 28 (57%) partial response, 4 (8%) stable and 5 (10%) progression. One biliary stenosis, requiring internal and external biliary drain and 2 clinically insignificant biliary intrahepatic ductal dilatations were observed. No bilomas or abscess were seen. 6 (5.9%) embolizations resulted in grade 3 toxicities, all but 2 were transient. 1(1%) death occurred within one month of embolization. Post procedure non-contrast-enhanced CT after TACE with 40 μM Oncozene adequately allowed for evaluation of target lesion uptake and for non-target embolization.

Conclusions: TACE with 40 μM DEBs clinical safe, has minimal adverse events, good objective response rate and promising survival after one year. Post embolization non-contrast-enhanced CT of 40 μM Oncozene can serve for assessment of tumor uptake and non-target embolization.

Scientific Session 5

Ablation: Lung

Sunday, March 18, 2018
3:00 PM–4:30 PM
Room: 406A

Comparison of ablation at high-volume centers with stereotactic body radiation therapy in early-stage primary non-small cell carcinoma: a National Cancer Database study

A. Lam1, E. Yoshida2, K. Bui1, J. Katrivesis1, D. Fernando3, K. Nelson1, N. Abi-Jaadudeh1; 1University of California, Irvine, Orange, CA; 2Cedars-Sinai Medical Center, Los Angeles, CA

Purpose: To compare overall survival (OS) following ablation at high volume centers (HVC) and stereotactic body radiotherapy (SBRT) in patients with early-stage, non–small cell lung cancer (NSCLC).

Materials: The National Cancer Database was queried for cases of NSCLC with American Joint Committee on Cancer 7th edition clinical T1aN0M0 and T1bN0M0 disease treated with ablation or SBRT from 2004-2014. Patients treated with ablation at low-volume centers, defined as facilities below the 95th-percentile in number of ablations performed and equating to less than 13 patients treated, were excluded. Differences between groups were assessed with Mann-Whitney U or Pearson chi-square analysis. The Kaplan-Meier method was used to estimate OS and comparisons between survival curves were performed with the log-rank test. Propensity score matched cohort analysis was performed to
adjust for measurable confounders. A p-value of <0.05 was considered statistically significant.

**Results:** The final cohort consisted of 13,358 cases of SBRT and 335 cases of HVC ablations, totaling 13,693 cases. Estimated median survival and follow-up times were 38.8 and 42.0 months, respectively. Patients treated with ablation had significantly higher income (p < 0.001), higher education (p = 0.032), more comorbidities (p < 0.001), and lower stage disease (p < 0.024), compared to patients treated with SBRT. Patients treated with ablation were more likely to be managed in an academic center (p < 0.001) and have private insurance (p = 0.009). No significant differences persisted following propensity score matching. No difference in OS for the unmatched groups was found, with 1-, 3-, and 5-year survival of 87.3%, 53.4%, and 31.3%, in the SBRT group versus 89.8%, 52.1%, and 26.0%, in the ablation group (p = 0.214). No difference was found in the matched groups, with 1-, 3-, and 5-year survival of 87.7%, 54.2%, and 29.6%, in the SBRT group versus 89.7%, 52.2%, and 26.1%, in the ablation group (p = 0.251).

**Conclusions:** This retrospective, propensity-score matched analysis demonstrates no significant difference in OS for patients with early-stage NSCLC treated with ablations performed at HVCs compared to SBRT.

**3:10 PM Abstract No. 44**

**Thermal ablation and stereotactic radiation therapy for stage I NSCLC: contemporary trends and outcomes from the National Cancer Database**

*J. Uhlig*, S. Gettinger*, S. Goldberg*, H. Kim*

*1University Medical Center Goettingen, Goettingen, Germany; 2Yale School of Medicine, New Haven, CT*

**Purpose:** To investigate utilization of thermal ablation for management of stage I non–small cellular lung cancer (NSCLC) compared to stereotactic radiation and evaluate associated outcomes.

**Materials:** Patients treated with thermal ablation or stereotactic radiation for stage I NSCLC diagnosed between 2004 and 2013 were retrospectively studied using the National Cancer Database (NCDB). Patients were excluded if receiving chemotherapy or immunotherapy. Propensity score models (nearest neighbour method) were used to 1:1 match patients receiving ablation and radiation, resulting in a cohort with balanced distribution of baseline variables. Overall survival was analyzed using Kaplan Meier plots and Cox proportional hazard models in the matched cohort.

**Results:** 1,058 patients receiving thermal ablation and 22,415 patients receiving stereotactic radiation fulfilled the inclusion criteria. Thermal ablation patients were in general older and had more comorbidities. Sociodemographic factors associated with thermal ablation treatment were white race, private insurance or Medicare, high median household income, rural residency, smaller tumor size and treatment in an academic center. Patients residing in Middle Atlantic or New England states had a higher likelihood of treatment by thermal ablation. In the 1:1 matched cohort with balanced distribution of baseline variables (including age, gender, comorbidities, socio-demographic and cancer factors), overall survival was comparable for both treatment subgroups with a median survival for thermal ablation of 36.4 months versus 35.3 months for patients receiving stereotactic radiation (log rank p-value 0.939). Cox proportional hazards regression showed a survival benefit for patients treated by thermal ablation, although results did not reach statistical significance (HR = 0.97, 95% CI: 0.87-1.08, p = 0.57).

**Conclusions:** NSCLC treatment by thermal ablation shows substantial variation depending on patient characteristics and sociodemographic factors. Overall survival for thermal ablation is comparable with stereotactic radiation. In light of these findings, further studies should evaluate whether thermal ablation is a cost-effective alternative to stereotactic radiation.

**3:20 PM Abstract No. 45**

**Thoracic cryoablation for palliation of tumors in chest wall and pleura**

S. Mirzan*, A. Huang*, A. Muniappan*, C. Keyes*, E. Choy*, R. Uppot*, F. Fintelmann*

*1Massachusetts General Hospital, Boston, MA*

**Purpose:** To evaluate safety and efficacy of percutaneous cryoablation for palliation of primary and secondary tumors to chest wall and pleura.

**Materials:** An IRB approved, retrospective analysis identified 30 patients (19 men, 11 women; mean age 61 ± 11.8 years; range 34-81) at an academic tertiary medical center who underwent a total of 34 thoracic cryoablation procedures between March 2012 and September 2017 using CT-guidance. Imaging studies and medical record were reviewed to extract tumor location and histology. Procedural details including device, probe number and type, treatment protocol, intraprocedural anesthesia and complications were collected. Pre- and posttreatment pain level and change in pain medication was also collected, in addition to duration of reported pain relief.

**Results:** Cases were selected with input from a multidisciplinary tumor board. Tumors ranged from 1 to 11 cm in size and included mesothelioma, and metastases from osteosarcoma, breast cancer, non–small cell lung cancer, renal cell carcinoma, adenoid cystic carcinoma, thymoma, hepatocellular carcinoma, colon adenocarcinoma, and medullary thyroid carcinoma. Clinical and imaging follow-up was available for an average of 13 months (range, 1-57 mos). A dual-freeze protocol and 2-6 cryoprobes were used, depending on the size and number of targeted lesions. All cases were performed under general anesthesia and intercostal nerve block was performed with 0.5% bupivacaine at the end of the procedure. One patient received peri-procedural antimicrobial coverage given the presence of a chest wall implant. There were no immediate complications. Pain scores and need for pain medication decreased in all cases. Duration of treatment response was variable.

**Conclusions:** Cryoablation for palliation of tumors in chest wall and pleura is safe and effective. Our presentation details how to prevent intraoperative complications and to maximize patient benefit.

**3:30 PM Abstract No. 46**

**Cryoablation of lung tumors: a safe, well-visualized, and effective treatment option**

H. Aoun*, P. Littrup*, S. Abdelhadi*, M. Ritz*, M. Prus*, B. Adam*, B. Nahab*, Karmanos Cancer Institute, Detroit, MI; 2Crittenton Hospital, Bloomfield Hills, MI; 3Wayne State University/Dmc, Detroit, MI; 4Beaumont
Purpose: To assess technical feasibility, efficacy, and complication rates of CT-guided cryoablation of lung tumors in multiple locations.

Materials: CT fluoroscopic-guided percutaneous cryoablation was performed in 283 procedures on 379 lung tumors in 164 patients. There were 121 primary lung tumors and 258 metastatic lung tumors ablated. Tumor and ablation volumes, location, abutting vessels >3 mm, recurrences, and PFT’s were reviewed for all patients. Complications were graded by the National Institutes of Health, Common Terminology of Complications and Adverse Events 4.0 (CTCAE).

Results: All procedures were performed with conscious sedation. Mean FEV1 and DLCO2 for primary tumors were 73.6% (25-145%) and 62.1% (27-96%); and for metastatic tumors were 86.6% (32-144%) and 76.9% (29-110%), respectively. Overall tumor and ablation mean size was 2.4 cm (0.5–12.3 cm) and 4.5 cm (2.1-12.8), respectively. Total major complication rates were only 4.9% (14/283), and were statistically significant for ablated primary central (6/47) versus peripheral (8/158) tumors (p < 0.05). However, recurrence rates were significant for major complications with central tumors or major vessel proximity (p < 0.05). Pneumothorax occurred in 112 procedures (39.6%) of which 50 (17.7%) required immediate suction or short-term chest tube (<24hours) and only 8 (2.8%) procedures required prolonged chest tube (>grade 3). Recurrence rates of 6.3% (24/379) were greater in tumors >3 cm (12.9% N = 12/85) vs tumors <3 cm (4.1% N = 12/294) (p < 0.001). Recurrence rates for ablated metastatic tumors were not significantly different for central (8/100) versus peripheral (8/158) tumors (p > 0.1). However, recurrence rates were significant for ablated primary central (6/47) versus peripheral (2/74) lung tumors (p < 0.05).

Conclusions: CT-guided percutaneous cryoablation of lung tumors provides a low morbidity alternative with high efficacy for all tumor locations.

3:40 PM  Abstract No. 47

Characterization of in vivo ablation zones following percutaneous pulmonary cryoablation: expected and experimental findings

G. Lyons1, R. Winokur2, B. Pua2; 1NewYork- Presbyterian Hospital, New York, NY; 2Weill Cornell Medicine, New York, NY

Purpose: To determine the in vivo ablation zone when treating pulmonary tumors with cryoablation, with attention to differences in probe type, probe number, and anatomical factors.

Materials: CT imaging was reviewed retrospectively following cryoablation of lung tumors using Galil Medical cryoprobes with a triple freeze protocol. Postprocedure volume of the ablation zone was calculated by measuring the maximum axial diameter (2a) and 90° orthogonal diameters (2b and 2c), and applying the formula for volume of an ellipsoid: \(\frac{4}{3}\pi abc\). Statistical comparison was calculated using a student’s t-test or 1-way ANOVA. Linear regression was used to model ablation size with respect to probe number or distance to pleura or vessel. Graphical plots were created using the equation for an ellipse: \(x^2/a^2+y^2/b^2 = 1\).

Results: Mean volume of in vivo lung ablation with a single 17-gauge cryoprobe measured 3.0 cm\(^3\) (95% CI [2.3, 3.6], n = 15), a significant difference compared to the manufacturer published -40°C isotherm volume of 7.1 cm\(^3\) in room temperature gel (p < 0.001). Mean ablation volume of a larger 13-gauge cryoprobe was 4.3 cm\(^3\) (95% CI [1.7, 6.9], n = 2), which was not significantly different compared to the smaller 17-gauge probe (p = 0.22). Mean cryoablation zone was not significantly affected by nodule distance to the pleura (p = 0.54) or distance to a vessel larger than 3 mm in diameter (p = 0.55). Ablation volume was significantly increased (p < 0.001) with the use of multiple cryoprobes, at a rate of 10.8 cm\(^3\) increase per additional probe (2 probes: 12.9 cm\(^3\), 95% CI [8.2, 17.6], n = 24; 3 probes: 25.3 cm\(^3\), 95% CI [8.0, 42.6], n = 5). The increased ablation zone size with multiple probes was more attributable to increased short axis length (9.6 mm increase per probe) compared to the long axis (5.6 mm increase per probe).

Conclusions: The in vivo effective ablation zone differs significantly from manufacturer supplied specifications in pulmonary cryoablation. Ablation zone volume is increased by utilizing more cryoprobes, but not affected by cryoprobe gauge or proximity to pleura or vessel.

3:50 PM  Abstract No. 48

Comparison of conventional and cone-beam computed tomography for guiding and assessing pulmonary microwave ablation

E. Meram1, C. Longhurst1, C. Brace1, P. Laeselect1; 1University of Wisconsin - Madison, Madison, WI

Purpose: Cone-beam computed tomography (CBCT) is widely utilized for guiding interventional procedures, yet there is limited data on its diagnostic accuracy for thermal ablation in lung. We compared CBCT with conventional CT (cCT) for assessing the growth and postprocedural appearance of pulmonary microwave ablation (MWA) zones.

Materials: A total of 17 MWAs were performed in porcine lung in vivo by applying 65 W for 5 minutes through a single 17-gauge antenna. Either cCT (n = 8) or CBCT (n = 9) was used for guidance and ablation zone monitoring at one-minute intervals. Postprocedural noncontrast images were acquired with both modalities. Three independent readers (1-13 years experience) measured the length, width, cross-sectional area, and circularity of the ablation zones on gross tissue samples, cCT and CBCT images. The measurements were compared via linear mixed effects models for postprocedural appearance and with a polynomial mixed effects model for ablation zone monitoring.

Results: On postprocedural cCT and CBCT images, the differences in mean length, width, area, and circularity were not statistically significant (p > 0.05, Table 1). Also, there was no significant difference between cCT and CBCT growth curves of the ablation zones during monitoring (p > 0.05). cCT and CBCT tended to overestimate gross pathologic observations of ablation length, width, and area (Table 1).

Conclusions: CBCT was comparable to cCT when assessing the growth, final size, and shape of pulmonary microwave ablation zones and may be useful for monitoring and evaluating microwave ablations in lung.
Patient and facility demographics-related outcomes in early stage non–small cell lung cancer treated with ablation: a National Cancer Database analysis

A. Lam1, E. Yoshida2, K. Bui1, J. Katrivesis1, D. Fernando1, K. Nelson1, N. Abi-Jaoudeh1; 1University of California, Irvine, Orange, CA; 2Cedars-Sinai Medical Center, Los Angeles, CA

Purpose: To determine facility and patient demographics associated with survival disparities in early stage non–small cell lung cancer (NSCLC) treated with ablation.

Materials: The National Cancer Database was queried for cases of NSCLC with American Joint Committee on Cancer 7th edition clinical T1aN0M0 and T1bN0M0 disease treated with primary ablation from 2004-2014. Patients who received systemic therapy and radiotherapy were excluded. High-volume centers (HVCs) were defined as the top 95th-percentile of facilities by number of ablations performed. Differences between groups were assessed with Mann-Whitney U or Pearson chi-square analysis. Multivariate regression analyses were accomplished with Cox proportional hazard models. The Kaplan-Meier method was used to estimate overall survival (OS) and comparisons between survival curves were performed with the log-rank test. Propensity score matched cohort analysis was performed to adjust for measurable confounders. A p-value of <0.05 was considered statistically significant.

Results: The final cohort consisted of 967 cases. Estimated median survival time was 33.1 months (95% CI: 30.6 – 35.7). Estimated median follow-up time was 62.5 months (95% CI: 58.0 – 67.1). Among 305 facilities, 15 were determined to be HVCs, treating 13 or more patients from 2004 to 2014. A total of 335 cases (34.6%) from the final cohort were treated at HVCs. On multivariate Cox regression analysis, treatment at a HVC was associated with worse OS. Increasing age (HR = 1.022; CI 1.003 – 1.022; p = 0.013) and higher stage of disease (HR = 1.170 – 1.655; p < 0.001) were independently associated with worse OS.

Conclusions: Following propensity score adjustment, patients with early-stage NSCLC treated with ablation at HVCs experience a significant increase in OS, suggesting regionalization of lung cancer management as a means of improving outcomes.

Table 1.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Histology</th>
<th>cCT</th>
<th>CBCT</th>
<th>cCT versus CBCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
<td>SE</td>
</tr>
<tr>
<td>Width</td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
<td>SE</td>
</tr>
<tr>
<td>Area</td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
<td>SE</td>
</tr>
<tr>
<td>Circularity</td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
<td>SE</td>
</tr>
</tbody>
</table>

4:00 PM Abstract No. 49

Intratumoral radiofrequency hyperthermia-enhanced herpes simplex virus thymidine kinase (HSV-TK) gene therapy of orthotopic lung cancer through the augmentation of apoptosis and heat shock protein (HSP70) expression pathway

P. Li1, F. Zhang1, Q. Weng1, L. Zhao1, Y. Zhou1, Y. Li1, Q. Li2, X. Yang3; 1University of Washington School of Medicine, Seattle, WA; 2First Affiliated Hospital of Soochow University, Suzhou, Jiangsu

Purpose: To investigate the associated biomolecular mechanisms of intratumoral RFH-enhanced local HSV-TK/ganciclovir (GCV)-mediated suicide gene therapy of rat orthotopic lung cancers.

Materials: Human lung cancer cells (A549) transduced with Luciferase/mCherry/lentivirus and 24 nude rats with orthotopic lung cancers were divided into four study groups with treatments of (i) intratumoral HSV-TK/GCV gene therapy followed by RFH at 41-42 °C for 30 minutes; (ii) HSV-TK/GCV therapy alone; (iii) RFH alone; (iv) PBS as a control. Flow cytometry, bioluminescence assay and confocal microscopy were used to determine the apoptosis and viability of cells. Bioluminescence optical imaging was used to evaluate the changes of bioluminescent signals among the groups over 2 weeks. The expression of Bcl-2/Bax, Caspase-3 and HSP70 protein levels were assessed by western blotting (WB) and immunohistochemical (IHC) staining respectively.

Results: Compared with gene therapy alone, RFH alone or PBS, combination therapy induced the lowest cell viability (30.56 ± 9.12% VS 65.47 ± 8.02% VS 89.95 ± 6.33% VS 100% P<0.05), the highest cell apoptosis (20.05 ± 2.12% VS 9.87 ± 2.02% VS 4.31 ± 4.31% VS 3.12 ± 1.03%, P<0.05), and a remarkable decrease of relative bioluminescence signal (16.54 ± 0.12% VS 54.8 ± 0.10% VS 85.01 ± 0.08% VS 100%, P<0.01). Optical imaging showed a markedly decreased bioluminescence signal of the tumor in combination therapy (1.29 ± 0.18 VS 1.76 ± 0.13 VS 2.26 ± 0.17 VS 2.94 ± 0.15, P<0.05). Both WB analysis and IHC staining displayed the significantly decreased expression of Bcl-2 (1.03 ± 0.28 VS 2.15 ± 0.33 VS 3.48 ± 0.12 VS 3.87 ± 0.17 ± 107 IOD, P<0.01), as well as increased expression of Bax (3.30 ± 0.36 VS 2.02 ± 0.20 VS 1.46 ± 0.31 VS 1.26 ± 0.07, 107 IOD, P<0.01), Caspase-3 (5.58 ± 0.52 VS 3.36 ± 0.29 VS 1.42 ± 0.34 VS 1.21 ± 0.52, 107 IOD, P<0.05) and HSP70 (8.02 ± 0.05 VS 4.87 ± 0.42 VS 1.63 ± 0.23, 107 IOD, P<0.01) in cancer tissues of combination therapy group.

Conclusions: Intratumoral RFH-enhanced suicide gene therapy on rat orthotopic lung cancers through the mechanisms of augmenting apoptosis and the expression of HSP-70 pathway, which may provide additional insights to further improving treatment of lung cancers.
Venous: IVC Filters

Sunday, March 18, 2018
3:00 PM–4:30 PM
Room: 406B

3:00 PM Abstract No. 51

The influence of inferior vena cava filters on the rate of pulmonary embolism in patients with deep venous thrombosis: a population-based study

M. Khan, T. Daileda, J. Kuban, S. Yevich, S. Huang, S. Sabir, K. Ahrar, A. Tam, S. Gupta, S. Sheth, R. Sheth; 1MD Anderson Cancer Center, Houston, TX; 2University of Texas McGovern School of Medicine, Houston, TX; 3UT/MD Anderson, Houston, TX; 4MD Anderson, Houston, TX

Purpose: Inferior vena cava (IVC) filters are placed to reduce pulmonary embolism (PE) rates in patients with lower extremity deep venous thrombosis (DVT), though the evidence supporting this practice is limited. The purpose of this study was to evaluate the influence of IVC filter placement on preventing the development of PE in patients with DVT.

Materials: Using administrative data from all discharges from acute care hospitals in California (2005-2011) and Florida (2005-2014), patients with an initial presentation of DVT without PE were identified. All hospital visits for these patients were then evaluated for the placement of an IVC filter, the development of PE, as well as bleeding and venous thrombosis risk factors. The influence of IVC filter placement on PE rates was estimated using a propensity score matching algorithm.

Results: A total of 256,923 patients were identified who accounted for 1,590,610 hospital encounters. 72,383 (28%) patients underwent IVC filter placement; 59,016 (23.0%) underwent IVC filter placement within 30 days of initial DVT diagnosis. IVC filter patients had higher rates of bleeding risk factors including intracranial hemorrhage (4.9 vs 2%, P < 0.001), GI bleed (10.5 vs 5.9%, P < 0.001), and hematuria (4.4 vs 2.3%, P < 0.001). IVC filter patients had higher rates of proximal DVT (54.2% vs 46.1%, P < 0.001) as well as thrombosis risk factors including malignancy (19.7 vs 17.4%, P < 0.001), lower extremity fracture (1.9 vs 0.9%, P < 0.001), and coagulopathies (11.3% vs 8.5%, P < 0.001). A total of 10,432 (4.1%) patients were diagnosed with PE after the initial DVT presentation. After adjusting for these risk factors as well as anti-coagulation use by a propensity matching algorithm, patients who received an IVC filter were noted to have a significantly lower rate of PE (3.9% vs 6.7%, P < 0.001) than patients who did not receive an IVC filter.

Conclusions: In patients with DVT and bleeding risk factors, IVC filter placement is associated with a decreased rate of pulmonary embolism.

3:09 PM Abstract No. 52

Risk factors for adverse events following inferior vena cava filter placement: analysis of 69,588 cases

D. Kestenbaum, M. Finkelstein, R. Lookstein, E. Kim, F. Nowakowski, R. Patel, V. Bishay, M. Ranade, A. Fischman; 1Mount Sinai Hospital, New York, NY; 2Icahn School of Medicine at Mount Sinai Hospital, New York City, NY; 3Mount Sinai Medical Center, New York, NY; 4Icahn School of Medicine at Mount Sinai, New York, NY

Purpose: Improved inferior vena cava filters (IVCF) have led to liberalization of the indications for insertion, however, sparse data exists identifying risk factors for adverse events (AEs) following IVCF placement. In this study, we identify potential factors and analyzed their association with three quality of care metrics: 30-day readmission, 1-year mortality, and long hospital stay.

Materials: The New York Statewide Planning and Research Cooperative System, which covers all emergency room visits in New York State, was queried from 2007 to 2014 for emergent IVCF insertion (ICD-9 38.7). The American Hospital Association Dataviewer was used to supplement each procedure with information on the associated facility. High-volume physicians and high-volume hospitals were identified such that each accounted for 25% of all cases. The cutoff for long stay (>22 days) was set such that 25% of cases could be considered long stays. Multivariate analysis was performed to determine adjusted odds ratios, taking into account age, ethnicity, race, insurance, comorbidities, hospital teaching affiliation, hospital setting, and procedure year.

Results: A total of 69,588 cases were identified. Of these, 22,401 (32.2%) were identified as following a pulmonary embolism (PE), 33,866 (48.7%) were identified as being related to a deep vein thrombosis (DVT) only, and 13,321 (19.1%) did not have DVT or PE listed as a diagnosis, but were presumably at high risk for a venous thromboembolic event. Female gender and IVCF placement performed more recently were found to be protective for all three quality of care metrics, while procedures performed by high-volume physicians were protective against long hospital stay and 30-day readmissions. Finally, African-American race was found to be associated with poorer outcomes in readmissions and long stay.

Conclusions: In the setting of IVCF placement, female gender and more recently placed IVCF were associated with improvement in all three of the quality of care metrics. Procedures
performed by high volume physicians were associated with decreased rates of long hospital stay and 30-day readmissions while African-American race was associated with increased rates of those same metrics.

3:18 PM  Abstract No. 53

Changes in two-dimensional perfusion angiography before and after inferior vena cava filter retrieval
A. Lam\(^1\), K. Bui\(^1\), M. Padgett\(^1\), E. Mendoza\(^1\), H. Javan\(^1\), B. Sadeghi\(^1\), S. Gunasekaran\(^1\), M. Secrist\(^1\), J. Katrivessis\(^1\), D. Fernando\(^1\), K. Nelson\(^1\), N. Abi-Jaoudeh\(^1\); \(^1\)University of California, Irvine, Orange, CA

**Purpose:** To investigate differences in hemodynamic flow parameters acquired in two-dimension (2D) perfusion angiography before and after inferior vena cava (IVC) filter retrieval.

**Materials:** IVC filter retrievals at a single institution were retrospectively reviewed. Standardized breath-hold, digital subtraction angiography was performed at 2-3 frames per second before and after retrieval, and 2D-perfusion images were reconstructed on a dedicated workstation (Philips Allura Xper FD20, Philips Medical Systems, Best, Netherlands). Changes in the density per pixel per second within a region of interest (ROI) were used to calculate contrast arrival time, time-to-peak (TTP), wash-in-rate (WIR), area under the curve (AUC), and mean transit time (MTT). Measurements were obtained inferior, superior, and at the level of the filter. Differences in the hemodynamic parameters before and after filter removal were assessed with Mann-Whitney U analysis. A p-value of <0.05 was considered statistically significant.

**Results:** At the level of the filter, the TTP was significantly longer before filter removal when compared to after, with mean times of 1.28 and 0.78 seconds, respectively (\(p = 0.042\)). The MTT inferior to the filter was longer before filter removal when compared to after, with mean times of 0.8 and 0.5 seconds, respectively. The WIR inferior to the filter was longer before filter removal when compared to after, with mean of 435 and 250 HU/second, respectively.

**Conclusions:** Preliminary data evaluating differences in flow parameters acquired in 2D-perfusion angiography before and after IVC filter retrieval demonstrate a significantly longer TTP when filters are in place, suggesting a functional hemodynamic delay secondary to filter presence.

3:27 PM  Abstract No. 54

Filter retrieval assessment score (FRAS) for improved approach to inferior vena cava filter retrieval
M. Elsayed\(^1\), A. Dabrowiecki\(^1\), P. Park\(^1\), K. Chandora\(^2\), Z. Bercu\(^1\), J. Newsome\(^1\), M. Miller\(^1\), D. Kies\(^1\), J. Martin\(^1\); \(^1\)Emory University School of Medicine, Atlanta, GA; \(^2\)Morehouse School of Medicine, Atlanta, GA

**Purpose:** Complex IVC filter (IVCf) retrieval may require deeper sedation, longer procedure time, larger sheath sizes, and alternative retrieval techniques. No objective scoring system exists to predict the complexity of IVCf retrieval. This retrospective study analyzes a new Filter Retrieval Assessment Score (FRAS) system designed to predict IVCf retrieval complexity and improve preprocedure planning.

**Materials:** A multi-hospital multi-institution retrospective analysis of IVCf retrievals between May 2013 to Sept 2017 was performed, including clinical data and procedural details. A FRAS classification was assigned as follows: Level 1, conventional retrieval snares and sheaths up to 12 French (Fr); Level 2, use of reverse curve loop snares, balloons, or sheaths greater than 12 Fr; Level 3, more than 1 venous access site; Level 4, endobronchial forceps or laser-assisted removal. FRAS 1/2 cases were compared against FRAS 3/4.

**Results:** A total of 259 attempted IVCf retrievals were performed in 243 patients. Total mean dwell time was 404.4 days and mean age was 56.2 years. There were 192 (74%) FRAS 1, 35 (14%) FRAS 2, 1 (0.4%) FRAS 3, and 31 (12%) FRAS 4 retrieval attempts. FRAS 3 and 4 retrievals had an increased dwell time, younger age, increased presence of thrombus during retrieval, longer fluoroscopy time, greater use of general anesthesia, and lower successful retrieval rates. There were no significant differences when comparing gender, BMI, creatinine, hypercoagulable state, or IVCf angulation.

**Conclusions:** Increased filter dwell time, younger age, and presence of thrombus are associated with increased case complexity. Awareness of these factors and utilization of the FRAS scoring system can be used to improve planning of IVCf retrieval.

3:36 PM  Abstract No. 55

Prepare to succeed: using a scoring system for complex inferior vena cava filter retrieval involving advanced filter retrieval techniques to guide device selection
P. Park\(^1\), Z. Bercu\(^1\), A. Dabrowiecki\(^1\), M. Elsayed\(^1\), J. Newsome\(^1\), M. Miller\(^1\), D. Kies\(^1\), J. Martin\(^1\); \(^1\)Emory University School of Medicine, Atlanta, GA

**Purpose:** To describe the use of a retrospective scoring system for complex IVC filter retrievals to guide device and sedation selection.
Materials: From February 2016 to April 2017, a total of 96 patients (52 females and 44 males; mean age, 58 years) underwent IVC filter retrieval at a single institution. Fifteen patients (16%) underwent complex filter retrieval using advanced retrieval techniques after an initial failed attempt with conventional filter retrieval technique. Each patient was retrospectively assigned a filter retrieval complexity score based on utilized techniques: Level 1: conventional retrieval snare and sheaths up to 12 French (Fr); Level 2: reverse loop snare, balloons, or sheaths greater than 12 Fr; Level 3: more than 1 venous access site; Level 4: endobronchial forceps or laser-assisted removal. One-way ANOVA with Post Hoc analysis was performed to compare means of filter dwell time among the four groups.

Results: Conventional IVC filter retrieval (Level 1) was performed in 81 patients (84.4%). 8 patients (8.3%) were Level 2, zero were Level 3, and 7 patients (7.3%) were Level 4. The average filter dwell time was 161 ± 134 days (Level 1), 219 ± 148 days (Level 2), and 923 ± 1077 days (Level 4). There was a statistically significant difference in the mean values among the groups overall (p < 0.001). Success was achieved in 12 of 15 (80%) patients who required a second intervention with use of techniques including endobronchial forceps; only 3 required laser-assisted removal.

Conclusions: Utilizing a preprocedural scoring system for complex IVC filter retrieval based on filter dwell time may help plan and manage the removal of problematic or embedded IVC filters in the interventional suite. Our scoring system will require future study and refinement, but for filter dwell times greater than 2 years, we recommend having endobronchial forceps in the suite, as this would have obviated the need for repeat procedures in 80% of cases.

3:45 PM Abstract No. 56

Excimer laser sheath–assisted retrieval of “closed-cell” design inferior vena cava filters
N. Xiao1, R. Lewandowski1, J. Karp1, R. Salem1, R. Ryu2, K. Desai1; 1Northwestern University, Chicago, IL; 2University of Colorado, Aurora, CO

Purpose: Inferior vena cava filters (IVCFs) with extended dwell times frequently become embedded and can present a significant technical challenge for retrieval. The use of the Excimer laser sheath has improved retrieval rates for IVCFs with caval wall incorporation; however, there are limited data on which IVCF designs more likely require laser sheath assistance at retrieval. This study aims to evaluate whether “closed-cell” IVCF are more likely to necessitate laser sheath-assisted retrieval relative to linear configurations; we hypothesize that “closed-cell” IVCF more frequently require laser sheath use to achieve retrieval success.

Materials: From 10/2011-9/2017, 296 patients with IVCF implanted for greater than 6 months or those that previously failed retrieval were scheduled for retrieval with the laser sheath available. The laser was only employed if the filter could not be explanted with customary traction/countertraction forces. We assessed laser use, technical success, IVCF dwell time, and adverse events (AE). Filters were separated by closed-cell (Gunther Tulip, Option, Option Elite, OptEase, TrapEase, Simon-Nitinol) and linear (Celect, Celect Platinum, ALN, G2/G2X, Eclipse, Denali, Recovery, Greenfield) designs. Logistic and linear regression models were constructed; significance was determined at p<0.05.

Results: Technical success was achieved in 98% (n = 290) of retrievals. Laser sheath assistance was required in 41% of patients (n = 121). There was no association between dwell time and laser sheath necessity (p = 0.95). Patients with closed-cell IVCF designs required laser sheath-assistance significantly more than those with linear strut designs (OR 13.4, 95%CI: 7.6-23.8, p<0.001). Of the closed cell IVCF, OptEase and Gunther Tulip filters necessitated the laser sheath most often (86% and 67%), while Celect filters necessitated the laser sheath the most among linear strut configuration IVCF (25%). A total of 12 AEs were encountered (4%, 11 minor, 1 major).

Conclusions: IVCF with closed cell designs are 13 times more likely to require laser sheath-assistance for successful retrieval. Application of these findings may improve procedural planning and technical success of the retrieval procedure.

3:54 PM Abstract No. 57

Do magnification spot radiographs increase detection of inferior vena cava filter fractures prior to removal compared to preprocedure CT?
V. Sotirchos1, S. Trerotola1, S. Stavropoulos1; 1Hospital of the University of Pennsylvania, Philadelphia, PA

Purpose: Knowing about a fractured IVC filter prior to removal attempt is critical to procedure planning. This study was done to determine if magnification spot radiographs acquired before attempting IVC filter removal have increased sensitivity compared to CT in the detection of filter fractures.

Materials: An IRB approved retrospective review of our prospectively collected database of complex IVC filter removals from March 2016 to May 2017 was performed. Magnification spot radiographs (frontal and at least two oblique views) are obtained prior to venous access for filter removal. Patients were included in the study if an abdominal CT before filter removal was available for evaluation. Blinded review of the preprocedure CT studies and spot radiographs for the presence of filter fractures was performed. Concordance of the two imaging modalities was assessed and compared to inspection of the filter after removal.

Results: This study included a total of 83 patients (39 women and 44 men) with a mean age of 55 years (range, 23-84 years). The median time interval between the preprocedure CT study and the removal procedure was 28 days (range, 0-422 days). Removed filters included the Gunther Tulip (n = 24), the G2/G2X/Eclipse/Meridian (n = 19), the Celect/Celect Platinum (n = 15), the Option/Option Elite (n = 9), the Recovery (n = 8), the Denali (n = 6) and the OptEase (n = 2). Fractures were present in 26 filters (31%). Concordance of the blinded review of the two imaging modalities was 87% (72/83). On blinded review, sensitivity for IVC filter fractures was 62% (16/26) for CT and 92% (24/26) for spot radiographs. Nine of 10 false negative cases on CT were detected on spot radiographs, with a median time interval of 41 days (range, 2-175 days) between the two modalities for these cases.
Conclusions: Magnification spot radiographs acquired before attempting IVC filter removal may detect filter fractures not evident on CT and should be performed routinely, to allow for optimal treatment planning.

4:03 PM Abstract No. 58

Suprarenal inferior vena cava filter placement and removal: an analysis of safety, cost, and complications
A. Baheti1, N. Shah1, D. Sheeran2, J. Angle1, D. Gans3, S. Sabri2, L. Wilkins5; 1University of Virginia, Charlottesville, VA; 2University of Virginia Health System, Charlottesville, VA; 3University Hospitals - Cleveland Medical Center, Cleveland, OH; 4University of Virginia, Charlottesville, VA; 5University of Virginia, Charlottesville, VA

Purpose: To evaluate the safety, cost, retrieval rate, and complications of retrievable IVC filters placed in a suprarenal location.

Materials: A retrospective chart review of all patients receiving a retrievable suprarenal IVC filter in a tertiary care center over the previous 10 years was performed. Endpoints for the filter placement and removal procedures included sedation, fluoroscopy, and room time, procedure cost, location of filter within the cava, filter tilt, and clot within the IVC.

Results: 51 patients underwent suprarenal IVC filter placement with 27 returning for attempted filter removal. The mean age of suprarenal filter placement was 52.8, with no gender predilection. Tulip (n = 40), Denali (n = 10), and Celect (n = 1) filters were placed. The most common indication for filter placement was iliocaval thrombus (n = 19), followed by acute VTE and inability to anticoagulate (n = 17). The reasons for suprarenal placement, in descending order, were IVC thrombus (n = 20), anatomic restrictions (n = 17), external IVC compression (n = 8), IVC stenosis (n = 2), stented infrarenal IVC (n = 2), and pregnancy (n = 2). Of the anatomic reasons for suprarenal placement, duplicated IVC was the most common (n = 7). For placement procedures, the sedation time, fluoroscopy time, and room time in minutes were 60.2 ± 6.3 min, 8.45 ± 1.0 min, and 85.7 ± 4.8 min, respectively. The median cost was $1062.3. Retrieval was attempted in 27 (53%) of the filters placed. Of the 27 attempted retrievals, there was a 100% success rate in filter retrieval. There was a single complication in this series with fractured struts during filter removal. The mean dwell time was 57.5 days (range, 6 – 180 days). There was no significant change in craniocaudal filter position, filter tilt, or clot burden between placement and retrieval. The sedation, fluoroscopy, and room times for the retrieval were 73.1 ± 13.8 min, 14.7 ± 5.1 min, 90.9 ± 11.3 min. The median cost was $412.3.

Conclusions: Suprarenal IVC filters, when indicated, can be placed and retrieved safely, at comparable cost and with similar amount of resources as infrarenal filters, and with a low complication rate.

4:12 PM Abstract No. 59

Randomized controlled study of an absorbable vena cava filter in a porcine model
M. Eggers1, S. Dria1, S. Rousselle2, M. Urtz3, R. Albright3, A. Will3, B. Jourden3, C. Godshalk4, S. Huang5, J. Steele5; 1Adient Medical, Pearl, TX; 2Alizee Pathology, Thurmont, MD; 3Synchry Labs, Durham, NC; 4East Coast Veterinary Imaging, Stuart, FL; 5The University of Texas M.D. Anderson Cancer Center, Houston, TX

Purpose: To evaluate the long-term safety and efficacy of an absorbable vena cava filter compared to a benchmark IVC filter in a swine model.

Materials: A randomized controlled GLP study approved by an institutional animal care and use committee was performed with test and control cohorts of Domestic Yorkshire cross swine; 16 were implanted with an absorbable IVC filter (Adient Medical), while 8 were implanted with a Celect IVC filter (Cook Medical) respectively. All animals underwent fluoroscopic imaging consisting of pulmonary angiography and cavography pre- and post-deployment, 5 and 32 weeks. Terminal procedures and necropsy were performed at 32 weeks for all animals. The IVC, heart, lungs, liver, and kidneys were harvested at necropsy.

Results: All animals, with exception of one early death due to a recurring hemorrhage at the femoral access site (unrelated to the test device), remained clinically healthy throughout the duration with no major health issues. A summary of the endpoint results is given in the table, revealing that both test and control devices were equally effective in preventing PE; however, the absorbable filter proved safer by avoiding caval perforation and thrombus. The control filter routinely perforated the IVC and produced occasional collateral trauma to adjacent tissues (psos muscle and aorta). The veins implanted with the absorbable filter were macroscopically indistinguishable from normal adjacent veins at 32 weeks (except for the presence of the radiopaque markers). Non-target tissues showed no device related changes.

Conclusions: Implantation of the absorbable IVC filter in swine proved safe and effective, resulting in complete to near complete resorption of the filter polymer in 32 weeks with restoration of the normal appearance and structural properties of the IVC.

Randomized Controlled Study Results

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Test Device (n = 15)</th>
<th>Control Device (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adient Absorbable IVC Filter</td>
<td>Cook Celect IVC Filter</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Filter migration (5 wk)</td>
<td>3-8 mm</td>
<td>6-20 mm</td>
</tr>
<tr>
<td>IVC perforation</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Perforation grade</td>
<td>0</td>
<td>6 grade II, 2 grade IV</td>
</tr>
<tr>
<td>IVC thrombus</td>
<td>0%</td>
<td>75%</td>
</tr>
<tr>
<td>IVC stenosis (mild)</td>
<td>13%</td>
<td>25%</td>
</tr>
</tbody>
</table>

4:21 PM Abstract No. 60

Machine learning detection and classification of inferior vena cava (IVC) filters from radiographs to enrich registries of patients with retrievable IVC filters
A. Vezeridis1, S. H. Chang2, A. Aryafar3; 1UC San Diego Health, LA Jolla, CA; 2Cheng Hsin General Hospital, New Taipei City, Taiwan; 3UC San Diego Health, San Diego, CA

Purpose: To evaluate the long-term safety and efficacy of an absorbable vena cava filter compared to a benchmark IVC filter in a swine model.
Purpose: Inferior vena cava (IVC) filters are commonly encountered on radiographs of the abdomen, lumbar spine, and pelvis but are typically not identified in study reports according to their type and whether they are retrievable or not. We hypothesized that standard machine learning techniques including image analysis by convolutional neural networks (CNNs) would be able to differentiate between various types of IVC filters, and that these automatic classification methods could serve as a useful method to enrich registries of patients with IVC filters. Such patients may in turn be candidates for IVC filter retrieval.

Materials: 530 radiographs of twelve categories of IVC filters were collected and regions of interest labelled manually with type of IVC filter. Standard image augmentation strategies were used to increase the number of training images. Transfer learning techniques were employed to retrain the Inception v3 convolutional neural network (CNN), part of the open-source Tensorflow framework, to detect and classify the twelve categories of IVC filters. The accuracy of the retrained network was then evaluated by a set of 24 IVC filter radiographs not previously seen by the network.

Results: The retrained network required 14 minutes to train on the augmented set of 5300 radiographs using CPU-only techniques and 8000 learning steps. Final test accuracy achieved was 80%, with training set accuracy up to 96%. In a set of 24 test images that the network had not previously seen, it correctly identified 75% of 12 classes of IVC filters. Confidence scores for correct identification of the filters were mainly clustered between 90-99% (range, 51-99%). The network was inaccurate on images of low brightness and contrast. The network could distinguish between similar-appearing filters with high confidence, such as between OptiEase and TrapEase filters, and between Tulip and Celect filters.

Conclusions: In summary, we have trained a convolutional neural network to accurately identify and classify 12 classes of IVC filters. The accuracy of the retrained network was then evaluated by a set of 24 IVC filter radiographs not previously seen by the network.

Purpose: Inferior vena cava (IVC) filters are commonly encountered on radiographs of the abdomen, lumbar spine, and pelvis but are typically not identified in study reports according to their type and whether they are retrievable or not. We hypothesized that standard machine learning techniques including image analysis by convolutional neural networks (CNNs) would be able to differentiate between various types of IVC filters, and that these automatic classification methods could serve as a useful method to enrich registries of patients with IVC filters. Such patients may in turn be candidates for IVC filter retrieval.

Materials: 530 radiographs of twelve categories of IVC filters were collected and regions of interest labelled manually with type of IVC filter. Standard image augmentation strategies were used to increase the number of training images. Transfer learning techniques were employed to retrain the Inception v3 convolutional neural network (CNN), part of the open-source Tensorflow framework, to detect and classify the twelve categories of IVC filters. The accuracy of the retrained network was then evaluated by a set of 24 IVC filter radiographs not previously seen by the network.

Results: The retrained network required 14 minutes to train on the augmented set of 5300 radiographs using CPU-only techniques and 8000 learning steps. Final test accuracy achieved was 80%, with training set accuracy up to 96%. In a set of 24 test images that the network had not previously seen, it correctly identified 75% of 12 classes of IVC filters. Confidence scores for correct identification of the filters were mainly clustered between 90-99% (range, 51-99%). The network was inaccurate on images of low brightness and contrast. The network could distinguish between similar-appearing filters with high confidence, such as between OptiEase and TrapEase filters, and between Tulip and Celect filters.

Conclusions: In summary, we have trained a convolutional neural network to accurately identify and classify 12 classes of IVC filters. The accuracy of the retrained network was then evaluated by a set of 24 IVC filter radiographs not previously seen by the network.
Therefore, for initial tube placement, large-bore LR catheters may significantly reduce the number of overall complications. Compared to BR catheters, LR catheters had significantly fewer complications (p = 0.01) but not minor complications (p = 0.052). There were no significant differences in the number of total complications, including major or minor complications, between LR and PT catheters or between BR and PT catheters.

Conclusions: Use of BR, LR, and PT devices for RIG is safe with a low incidence of complications. Compared to BR catheters, primary insertion of a LR gastrostomy was associated with significantly fewer overall complications within the first 30 days. Therefore, for initial tube placement, large-bore LR catheters may be preferred over BR devices.

3:18 PM Abstract No. 63

The role of IR, GI, and surgery in gastrostomy tube placement for Medicare beneficiaries
M. Said1, I. Moreno2, B. Roudsari2; 1UC Davis School of Medicine, Sacramento, CA; 2UC Davis Medical Center Department of Radiology, Sacramento, CA

Purpose: This study evaluates the role of IR, GI, and surgery in fluoroscopy and endoscopy-guided gastrostomy tube placements for Medicare beneficiaries. The specialty-specific charge of care, Medicare reimbursement, and state-level variability in aforementioned variables are evaluated.

Materials: Using Healthcare Common Procedure Coding System code and the “Provider Utilization and Payment Data Physician and Other Supplier Public Use File” database by Medicare, we identified claims regarding fluoroscopy and endoscopy-guided gastrostomy tube placements. The most recent data is for 2015. Charge to reimbursement ratio (CTRR) was calculated to reflect the Medicare overcharging by healthcare providers.

Results: In 2015, 503 providers (490 IR) submitted claims for percutaneous fluoroscopy-guided G tube placements. 4 claims were submitted by surgeons and 2 claims by radiation oncologist. The average physician reimbursement for inpatient fluoroscopy-guided G tube placement was $177 (range, $140 in VT and NV, $242 in AK, and $194 in NY and Washington DC). VT had the highest CTRR (43, based on only one provider), followed by WY (22) and NE (18). DE (3.0) and KY (3.5) had the lowest CTRR. A total of 2,268 providers submitted endoscopy-guided G tube placement claims. GI, general surgery, and internal medicine comprised 68%, 22%, and 6% of the claims, respectively. In TX, CA, and FL, more than 80% of the claims were submitted by GI. While, in DE, SD, and ME, 80%, 67%, and 67% of the claims were submitted by general surgery, respectively. The average physician fee reimbursements for GI and surgery were $165 and $140 for inpatient G tube placements. The overall reimbursements varied from $177 in IL to $219 in SD. SD (11) had the highest CTRR, followed by NJ (9.5), and NY (9.3). MN had the lowest CTRR (2.6).

Conclusions: This study demonstrated that IR almost exclusively provided fluoroscopy-guided G tube placements for Medicare beneficiaries. It also highlighted the role of GI and surgery in endoscopy-guided G tube placements. Significant national variability in the CTRR for both fluoroscopy and endoscopy-guided G tube placements was noted, while the difference in reimbursements was not as impressive.

3:27 PM Abstract No. 64

Radiological retrograde ureteric stent exchange: a large single-center review

Purpose: Safety and efficacy of fluoroscopy-guided retrograde transurethral replacement of ureteral stents as an alternative to cystoscopy-guided exchange has been proven. We assess our practice of retrograde stent exchange using an inexpensive modified wire loop snare technique.

Materials: All the patients are from our women’s hospital where there is no Urology cover. Patients were identified retrospectively from our radiological information system database. Between Jan 2012 and Dec 2016, there were 79 patients (mean age 55 years, range 32-79) of whom 14 underwent retrograde stent retrieval on the first visit and the rest underwent stent exchange. In total we retrieved 255 stents and replaced 241. The procedures were performed on an outpatient basis unless the patient was already an inpatient. Under fluoroscopic guidance, a 10F sheath was inserted into the urinary bladder through the urethra. Using a 0.018” Terumo wire loop as a modified snare, the distal end of the stent was withdrawn just outside the urethra. A 0.035” guidewire was then advanced into the renal pelvis through the stent and the old stent exchanged for a new one. Ureteroplasty was performed if there was contrast hold up.

Results: Stent exchange was successful in 237/241 (98%) of cases. Failure was due to loss of access (1 case), inability to snare stent due to distorted anatomy (2 cases) and inability to cross ureteric stricture (1 case). In 218 (90%) of cases other stent devices were used. Most of the patients tolerated the procedure well. 43/65 (66%) patients had regular 3-4 monthly exchanges till death or study end point. 10/65 (15%) no longer required ureteral stenting as there was resolution of ureteral obstruction. 10 were lost to follow-up or care transferred back to urologists and 2 no longer wished to be on ureteral stenting.

Conclusions: Fluoroscopy-guided retrograde ureteral stent exchange is safe, effective and quick and can be easily performed with equipment used in daily intervention practice. It may also be coupled with ureteroplasty, which may help the patient achieve eventual stent-free status.

3:36 PM Abstract No. 65

Ureteral stent placement prior to percutaneous nephrostomy is associated with decreased radiation dose and fluoroscopy time
E. Morris1, J. Horn1; 1New York University, New York, NY

Purpose: To identify patient and technical factors that contribute to increased radiation dose and fluoroscopy time during percutaneous nephrostomy placement.
Materials: Patients who underwent percutaneous nephrostomy (PCN) placement from January 2012 to June 2017 were identified. Degree of hydronephrosis was graded by consensus as grade 0 (none), 1 (mild), 2 (moderate), or 3 (severe) according to Society of Fetal Ultrasound criteria. Radiation dose and fluoroscopy time per PCN were recorded. Bilateral PCNs with two equal grades were considered two unique PCNs which equally shared radiation dose; bilateral PCNs with two different grades were excluded. Additional data, including presence of ureteral stent, laterality, simultaneous bilateral placement, and body mass index, were also collected. Statistical analysis was performed using Spearman rank correlation to assess association of hydronephrosis grade with dose and time, and ANOVA and ANCOVA tests compared dose and time without and with adjustment for BMI. Mann-Whitney test was performed to compare dose and time for procedures with and without stent.

Results: A total of 244 PCNs were performed on 185 patients (54.5% male, mean age 67.3 years). Hydronephrosis grade negatively correlated with both radiation dose and fluoroscopy time independent of BMI (p<0.001). The presence of a ureteral stent was associated with a large radiation exposure reduction across all grades of hydronephrosis, decreasing overall dose by 36.7% and time by 18.4%. The greatest reductions in dose and time in the presence of a stent were observed in the Grade 0 and 1 PCNs, with decreases of 54.8% for dose and 45.5% for time.

Conclusions: Presence of stent greatly reduces radiation dose and fluoroscopy time during PCN, particularly in obese patients with mild or no hydronephrosis who may be subject to very high radiation exposure. We propose that such measures as preprocedural cystoscopic ureteral stent placement if feasible or, by extension, intravenous pyelogram can provide the interventionalist with a target for percutaneous access, thereby reducing radiation exposure to both patient and practitioner.

3:45 PM  Abstract No. 66

Prognostic factors for clinical outcomes in patients with unresectable esophageal cancer after 125I-seed-loaded stent placement: a multicenter retrospective analysis

J. Qin1, G. Teng2, H. Zhu3; 1Zhong-da Hospital, Medical School, Southeast University, Nanjing City, Jiangsu Province; 2Zhong-Da Hospital, Southeast University, Nanjing, China; 3Zhongda Hospital, Nanjing, Jiangsu Province

Purpose: To identify the potential predictors of overall survival and relief of dysphagia in patients with unresectable esophageal cancer treated with 125I-seed-loaded stent placement.

Materials: From June 1, 2012, to March 31, 2016, a total of 201 patients with oesophageal cancer diagnosed with squamous cell carcinoma or adenocarcinoma (147 men; mean age ± standard deviation, 71 years ± 11), who underwent 125I-seed-loaded stent placement, were retrospectively identified in 5 hospitals in China. Cox regression models adjusted for stratification factors and a stepwise multivariate analysis were performed.

Results: Three independent prognostic factors were associated with overall survival: histology of tumor (squamous cell carcinoma vs adenocarcinoma; hazard ratio, 1.45; P = .046), Eastern Cooperative Oncology Group performance status score (< 2 vs ≥ 2; hazard ratio, 1.51; P = .013), and serum total protein concentration (≥ 66 g/L vs < 66 g/L; hazard ratio, 0.67; P = .023). Four independent risk factors, including age (≥ 71 years vs < 71 years; odds ratio, 2.01; P = .029), tumour location (superior vs inferior; odds ratio, 0.49; P = .049), tumour-node-metastasis (TNM) classification (IV vs II; odds ratio, 3.19; P = .025), and T stage (T4 vs T3; odds ratio, 0.27; P = .003), were significantly associated with the relief of dysphagia. Major complications and side-effects were severe chest pain in 24 (12.1%) patients, hemorrhage in 18 (9%), aspiration pneumonia in 24 (11.9%), fistula formation in 13 (6.5%), recurrent dysphagia in 15 (7.5%), and stent loss in 11 (5.5%).

Conclusions: Placement of 125I-seed-loaded stent appears to provide different improvement of overall survival and dysphagia relief in esophageal cancer patients with different clinical characteristic. Predictive factors identified in this analysis may be useful when making treatment decisions and designing future clinical trials.

3:54 PM  Abstract No. 67

Lymphatic embolization for the treatment of postprocedural inguinal lymphatic leaks

A. Smolock1, G. Nadolski1, M. Itkin2; 1University of Pennsylvania, Philadelphia, PA; 2Penn Medicine, Bala Cynwyd, PA

Purpose: Percutaneous lymphatic embolization has been described as an effective therapy for post-surgical lymphatic injuries to the thoracic duct. The goal of this study was to describe our initial experience with percutaneous lymphatic embolization to treat postprocedural inguinal lymphatic leaks.

Materials: Thirteen patients (7 males; median age 63 years) undergoing percutaneous inguinal lymphangiography for post-procedural inguinal lymphatic leak between 2015 and 2017 were retrospectively reviewed. Of these, no leak was identified in 3 patients, and so no embolization was performed. In 7 of 10 patients, lymphatic embolization alone was performed, and 3 of 10 patients underwent a combination of lymphatic embolization and lymphocele sclerosis. Etiology for inguinal lymphatic leakage included: femoral vessel catheterization for major surgery (5), urogynecological surgery (3), and endovascular procedures (2). Inguinal lymph nodes were accessed with a 25G needle under ultrasound guidance, and lymphangiography was performed through slow injection of lipiodol under intermittent fluoroscopy. Embolization was performed by directly injecting n-butyl cyanoacrylate (n-BCA) into a lymph node peripheral to the leak. Technical success was defined as successful embolization of the lymphatic leak. Clinical success was defined as lymphatic leak resolution. Complications were classified according to the Society of Interventional Radiology guidelines.

Results: Mean volume of dilute n-BCA used was 1 mL. Technical success rate was 100% (10/10). Clinical success rate was 80% (8/10). Two patients ultimately underwent surgical lymphatic treatment. The median number of times lymphatic embolization was performed to achieve clinical success was 1 (range, 1-2). In 2 of 8 successful cases, additional lymphocele sclerosis was performed 1 and 3 times, respectively. Median clinical follow-up was 1 month (range, 0-6 months). There were no major complications.

Conclusions: Percutaneous lymphatic embolization to treat postprocedural inguinal lymphatic leaks is an effective minimally
invasive management option that provides a safe and simple alternative to prolonged drainage and additional surgery.

4:03 PM Abstract No. 68

In vitro evaluation of n-butyl cyanoacrylate–iodized oil mixtures for lymphatic interventions

C. Pieper1, D. Kuetting2, H. Schild3; 1University Hospital Bonn, Bonn, Germany; 2University of Bonn, Bonn, NRW Germany; 3University Hospital Bonn, Bonn, Germany

Purpose: To investigate the properties of n-butyl cyanoacrylate (NBCA)–iodized oil (Lipiodol) mixtures for lymphatic interventions in an in vitro setup.

Materials: Polymerization times of different NBCA/Lipiodol mixtures (ratios 1:1 - 1:7) were investigated in a static and dynamic experimental setup. Eight different fluid samples were investigated: (A) lymph (triglycerides less than 50 mg/dl) n = 3; (B) chyle (triglycerides around 300 mg/dl) n = 3; (C) chyle (triglycerides > 700 mg/dl) n = 2. For evaluation of static polymerization time NBCA/Lipiodol was dropped on the fluid samples. Morphologic changes during polymerization were monitored and recorded by video. Additionally thoracic duct embolization was simulated in a dynamic flow model to measure dynamic polymerization times. A microcatheter was flushed with 40% glucose and used to inject NBCA/Lipiodol with different ratios into a silicon tube with slowly flowing lymph/chyle. All experiments were repeated five times.

Results: Static experiments showed increasing polymerization time with increasing Lipiodol content both in lymph and chyle. Polymerization time also increased with triglyceride concentrations (lymph (A): increase from 14sec (1:1) to 1336sec (1:7); chyle (B): from 21sec (1:1) to 2546sec (1:7); chyle (C): from 168sec (1:1) to 16530sec (1:7)). In dynamic experiments prolongation of polymerization time was less pronounced. In (A) and (B) total occlusion of the silicon tube was observed in all cases during the embolization procedure (between 26sec (1:1) and 52sec (1:7)). No differences were observed between (A) and (B). In (C) polymerization took considerably longer (between 43sec (1:1) and 467sec (1:7)). Occlusion with a 1:7 mixture in (C) failed in 4/5 experiments.

Conclusions: Polymerization time of NBCA/Lipiodol seems to be prolonged both by increasing NBCA/Lipiodol-ratios and by increasing triglyceride content of chylous fluid. Thoracic duct embolization with a high NBCA/Lipiodol-ratio in chylous fluid with high triglyceride content may therefore be problematic. We advocate the use of ratios between 1:1 and 1:3. Clinically, a decrease in triglyceride content is achieved by parenteral nutrition or diet before intervention.

4:12 PM Abstract No. 69

Tunneled peritoneal drainage catheter for refractory ascites: a single-center experience of 480 patients

T. Le1, D. Rosenthal2, Y. Kelleher3, C. Fiore1, C. Fan1, M. Stecker1; 1Brigham & Women’s Hospital, Boston, MA; 2Brigham & Women’s Hospital, Sharon, MA; 3Brigham & Women’s Hospital, North Easton, MA

Purpose: To evaluate the efficacy, safety, and complications of tunneled peritoneal catheters for the treatment of refractory ascites, and to assess for association between tumor type and catheter-related complications.


Results: 480 patients were reviewed (203 males, 277 females) in whom 489 catheters were placed (472 received 1, 7 received 2, and 1 received 3). Most patients (477; 97.5%) had malignant ascites. 25 patients were lost to follow-up. Malignant ascites was associated with an average catheter duration of 58.4 days compared to non-malignant ascites with average catheter duration of 83.4 days. Pancreatic (16.5%), ovarian (14.2%), breast (12.1%), and peritoneal carcinomatosis of unknown primary (8.4%) make up the majority of the causes of malignant ascites. Technical success rate was 100%. A total of 103 (20.2%) complications were identified, including access site leak (4.1%), catheter occlusion (3.5%), peritonitis (3.0%), inadequate drainage (2.8%), and cellulitis (2.6%). Pancreatic cancer has lower catheter duration (mean 40.7 days versus mean 61.3 days) among the 4 largest represented categories of malignancies. Rates of catheter related complications are relatively similar among malignancies frequently associated with ascites. 230 subjects died within 30 days of catheter placement (47.9%), and 363 died within 90 days of placement (75.6%).

Conclusions: Tunneled peritoneal catheters are advantageous for home drainage of patients with refractory ascites, but almost half of our subjects, most of whom had malignancy as the etiology of their ascites, died within 30 days of placement. Adverse events after placement are not uncommon, but most can be treated conservatively.

4:21 PM Abstract No. 70

Technical considerations and outcomes from the MOSAC study: a multicenter, open-label prospective study of the Alfapump system used for management of refractory ascites

E. Bendel1, K. Sniderman2, C. Shaw2, R. Frederick4, F. Wong5, A. Sanyal6, S. Asrani3, P. Kamath1, J. Capel7, Z. Haskal8; 1Mayo Clinic, Rochester, MN; 2Toronto General Hospital/University Health Network, Toronto, ON; 3Baylor University Medical Center, Dallas, TX; 4California Pacific Medical Center, San Francisco, CA; 5Toronto General Hospital, Toronto, ON; 6Virginia Commonwealth University, Richmond, VA; 7Sequana Medical AG, Zurich, Switzerland; 8University of Virginia, Charlottesville, VA

Purpose: To demonstrate the technical success, 3-month paracentesis requirements, and mean follow-up safety outcomes for the implantable/rechargeable subcutaneous pump (alfapump), which pumps ascites to the bladder for elimination.

Materials: An investigational-device multicenter, prospective, open-label, single-arm study was performed at 6 sites in N. America, enrolling 30 patients. The Sequana alfapump was implanted in 30 patients with refractory ascites in the setting of nonmalignant cirrhosis (alcoholic, 14), not eligible for TIPS. Primary endpoints were assessed at 3 months. Technical success,
reinterventions (RI), explants, and procedure-related adverse events (AEs) are reported per mean follow-up period.

**Results:** 30 patients (median 63y (32-72); 13F) were successfully implanted (29 IR). Technical success was 100%. There were three adverse events likely procedure-related, to include atypical pain at bladder catheter (BC) site (2) or abdomen (1). Average volume of ascites removed was 79.14 liters, ranging from 16.0 to 170.7L at 3 months. The paracentesis rate fell from 3.34 ± 2.46 per patient/month to 0.37 ± 0.57 when comparing 3 months prior to intervention to the follow-up period. 27 reached the 3-month follow-up period. 2 systems were explanted for cellulitis/pump-pocket infection and 1 for unrelated death from ESRD. Median study follow-up was 9.3M (1.1-16.9) and 8.8M (0.9-16.7) on treatment. By 3M, 4 RI were performed for peritoneal catheter (PC) replacement (3) and pump replacement (1). RI due to intrinsic pump malfunction was performed 8 times (7pts) at a mean of 8.9M (0-13.8). RI for BC issues included dislocation (2), blockage (1) and RI for PC issues occurred 9 times (dislocation 6, kink 1, pericatheter leak 1, disconnection 1) in 8 patients. Beyond 3M, there have been 7 additional explants for issues (infection 4, erosion/dehiscence 3, pump malfunction 1, fluid leak into pump pocket 1). 3 pumps were explanted in favor of liver transplant.

**Conclusions:** Implantation of this system is technically achievable using an IR skillset. Pump malfunction and peritoneal catheter malpositioning remain ongoing concerns, as well as infection-related AE. These topics would benefit from further studies and device development.

**Scientific Session 8**

**Practice Management**

Sunday, March 18, 2018
3:00 PM–4:30 PM
Room: 409A

**3:00 PM**

**Abstract No. 71**

Large medical center experience with moving outpatient paracentesis from hospital-based interventional radiology suite to outpatient clinic

G. Malyutin1, W. Culp1, D. Briscoe1, R. Li1, J. Meek1, M. Meek1; 2University of Arkansas for Medical Sciences, Little Rock, AR

**Purpose:** Ultrasound (US)-guided paracentesis uses sophisticated IR procedure rooms for long periods of time. We moved outpatients to a separate outpatient (OP) clinic and quantified our experience performing clinic-based US-guided large volume paracentesis.

**Materials:** A retrospective chart review of US-guided paracentesis procedures per month was conducted from May 2014 to August 2017. Data was analyzed using t-test. Institutional hourly IR suite rate was previously found to be $539/hr. July 2017 was chosen as a representative sample for the calculation of volume drained and time in the clinic. A total of 50 patients were scheduled for appointments in July 2017, 25 female and 25 male. Four patients were excluded, three with lack of fluid, and one no-show. Procedural technique was constant in both settings. Albumin was administered based on volume drained.

**Results:** A total of 723 paracentesis procedures (60.25/month) were performed last year in the OP clinic, Sept 2016-Aug 2017. The average fluid obtained from paracentesis in July was 4660 cc, and average duration of clinic visit was 104 minutes. Since opening, 1184 paracentesis procedures have been performed in the OP clinic. A significant increase was found in the total number of paracentesis procedures performed in the ten months prior to clinic opening (May 2014-Feb 2015) as compared to the current state (Nov 2016-Aug 2017). The average number of paracentesis procedures per month increased from 72.1 to 92.5, p = 0.0023. Moving procedures to the OP clinic decreased IR suite usage by 372 patients thereby decreasing IR suite time by 644 hours and shifting $349,184 of cost to the OP setting with potential savings. During the course of the study period, two of the 1184 patients in OP clinic required hospitalization, one for hypovolemia and one for syncope prior to the procedure.

**Conclusions:** By moving OP large-volume paracentesis patients from a hospital based IR suite to an OP clinic setting, we increased the total number of paracentesis procedures that we were able to perform while potentially decreasing cost.

**3:09 PM**

**Abstract No. 72**

Uterine fibroid embolization performed in an outpatient clinic reduces costs and increases productivity

N. Kisilevzky1, N. Fernandes2; 1Endovascular Center, Sao Paulo, Brazil; 2Endovascular Center, Sao Paulo, Brazil

**Purpose:** To report the results of a UFE program run in an outpatient clinic (OC) in comparison with those of a similar clinical program run in a regular general hospital (GH).

**Materials:** During a 4-year period (2013–2016), 825 patients were evaluated to have UFE. Overall, 711 patients met inclusion criteria for UFE. Patients were referred to perform the procedure either in an OC or in a GH. Clinical protocol and UFE technique were identical in both places. Differences were imaging facility (fixed machine in the GH vs mobile C arm in the OC) and revenue method (fee for service in the GH vs managed care in the OC). Decision to perform the procedure at each institution was taken upon insurance or patient approval.

**Results:** Overall, 188/359 (52.36%) patients underwent UFE in the OC, while 66/320 (20.62%) underwent UFE in the GH. There were no differences in supplies consumption, length of hospital stay, or outcomes. The mean total cost of UFE was $37,568.00 in the GH vs $23,490.00 in the OC.

**Conclusions:** Performing UFE in an OC is safe and efficient similar to performing the procedure in a GH. However, the lower price achieved in OC makes the procedure more attractive to be approved by insurance companies and patients having no insurance.
3:18 PM Abstract No. 73

Transjugular liver biopsy in a freestanding outpatient facility: safety and efficacy
D. Sperling1, V. Gioioso1, V. Sheynzon1, J. Susman1, D. Mobley1, P. Schlosberg1, S. Chheang1, S. Reis1, S. Brejt1, S. Tulin-Silver1, J. Weintraub1, Columbia University Medical Center, New York, NY

Purpose: The purpose of this abstract is to evaluate the safety and efficacy of transjugular liver biopsies (TJLB) when performed in a freestanding outpatient facility.

Materials: Patient data regarding all TJLB performed at a freestanding interventional radiology outpatient office was reviewed between July 2008 and March 2017. Data including patient age, gender, laboratory values (platelet count, INR, and creatinine) and the diagnostic rate of the pathologic specimen were analyzed. Most laboratory values were resulted within the preceding 3-6 months, with values included up to one year prior to the procedure. Specimen adequacy was determined by the pathology report and was considered non-diagnostic if the sample was deemed “limited,” “suboptimal,” or “non-diagnostic.” Complications were determined by chart review and included any unanticipated transfer to a hospital or return to a hospital for admission within 30 days of the procedure.

Results: During the time period evaluated, 437 TJLB were performed. 423 biopsies returned samples suitable for diagnosis. 12 biopsy samples were “limited” or “suboptimal” for pathologic evaluation. One sample returned no liver tissue. One sample returned kidney tissue. The diagnostic success rate on the 437 biopsies performed was 96.8% (423/437). The average patient age was 58 years (range, 19-86), with 172 performed on females (39.4%) and 265 performed on males (60.6%). The average platelet count was 170K (range, 30-620); 12 patients had a platelet count less than 50K. The average INR was 1.15 (range, 0.67-3.39); 30 patients had an INR > 1.5. The average creatinine was 2.27 (range, 0.32-22.53). No major complications occurred (0%, 0/437). Post-procedural recovery time was minimal (1-2 hours) and all patients were safely discharged home 1-2 hours following the procedure.

Conclusions: Transjugular liver biopsy is an extremely safe procedure yielding high diagnostic rates with no major complications. We submit that this procedure can be performed safely and effectively in a freestanding interventional radiology outpatient facility, without the need for the procedure to be performed in a hospital setting or for a pathologist to be present to evaluate specimen adequacy.

3:27 PM Abstract No. 74

Outpatient procedures for earlier discharge (OP-ED): a QI project to shorten length of stay
B. Sur1, A. Shulman1, K. Stewart1, S. McEnroe1, B. May2; 1New York Presbyterian Hospital Weill Cornell Medical Center, New York, NY; 2New York Presbyterian/Weill Cornell Medical Center, New York, NY

Purpose: To study the implementation and outcomes of a quality improvement initiative to reduce hospitalization length of stay by converting non-urgent, inpatient procedure requests to expedited outpatient procedures.

Materials: This QI initiative utilized the Plan Do Study Act (PDSA) method. A fishbone diagram summarizes contributors to the problem of patients, otherwise healthy enough for discharge, remaining hospitalized awaiting non-urgent procedures such as biopsy or mediport placement. Interdisciplinary planning between IR, oncology, internal medicine and social work identified various barriers to implementation. A pilot study was initiated for one month providing a short turnaround outpatient appointment at the time of inpatient consultation. Based on that analysis, two outpatient procedure room time slots were blocked weekly. Oncology partnered to review biopsy results for patients without established cancer diagnosis. Any barriers to discharge were addressed by social work.

Results: For 6 months period, total 84 cases were considered for OP-ED. Of those cases, 21 cases were successfully converted to outpatient procedures (25%). These cases were biopsy (11/21), port placement (4/21), tunneled central venous catheter placement (2/21), inferior vena cava filter placement (2/21), and transjugular intrahepatic portosystemic shunt (1/21). Mean and median waiting periods until the outpatient procedure were 9 days and 7 days respectively (range, 2-23 days). No patients were lost to follow-up. For those patients who declined conversion to outpatient procedure, mean and median waiting period was 3 days (range, 0-14 days). Compared to inpatient biopsies, outpatient biopsies resulted in insurance reimbursement gains ranging from $842.46 to $5,212.14 depending on insurance type. Outpatient port placement reimbursement gains ranged from $2,200.51 to $6,391.24.

Conclusions: Our study shows that transitioning non-urgent inpatient procedures to outpatient procedures with a systematic, multi-disciplinary approach can successfully reduce unnecessarily prolonged hospital stay. The hospital benefited with improved utilization of resources and improved reimbursement rates.

3:36 PM Abstract No. 75

Practice and institutional benefits from a Hereditary Hemorrhagic Telangiectasia Center of Excellence: practice patterns, services generated, and estimated downstream revenue from the Johns Hopkins Hereditary Hemorrhagic Telangiectasia Center of Excellence
C. Bailey1, M. Zolet2, M. Hoyer3, F. Ul Haq1, C. Merlo1, J. Collaco1, D. Reh1, G. Robinson4, P. Terry1, S. Mitchell5, C. Weiss6; 1Johns Hopkins Hospital, Baltimore, MD; 2Johns Hopkins University School of Medicine, Baltimore, MD; 3Johns Hopkins University School of Medicine, Baltimore, MD; 4The Johns Hopkins Hospital, Baltimore, MD; 5The Johns Hopkins University School of Medicine, Baltimore, MD; 6The Johns Hopkins University School of Medicine, Baltimore, MD

Purpose: Though Hereditary Hemorrhagic Telangiectasia (HHT) Centers of Excellence have been shown to provide HHT patients with effective multidisciplinary care, their positive effect on an individual practice and institution is not often discussed. We
highlight the effects of an organized HHT center of excellence on the practice patterns and services generated.

**Materials:** Patients who presented to our center of excellence between 2009 and 2013 were included in this IRB approved retrospective review. Patients underwent phone screening by a dedicated nurse coordinator trained in HHT diagnostic criteria. Patients with HHT were provided with an intake visit with pulmonology, then were triaged to subspecialty care. All patients underwent our standard pulmonary and cerebral arteriovenous malformation (AVM) screening. All procedures, office visits, and imaging studies related to HHT performed since the patient’s presentation to our center of excellence were recorded.

**Results:** A total of 286 patients enrolled between 2009-2013 (74 pediatric and 212 adults) were included in this study. The approximate cost of our dedicated nurse coordinator per year is $80,000 with fringe benefits included. From pulmonary arteriovenous malformation screening alone, this cohort generated 213 agitated saline Echos, 155 chest CTAs, 105 referrals to interventional radiology, 94 pulmonary angiography procedures, and 84 PAVM embolization procedures. In total our PAVM screening paradigm generated approximately $1.85 million in gross revenue or $370,000 per year (professional and technical fees summed). Cerebral AVM screening and treatment services and additional referrals to other subspecialists for indications such as epistaxis, gastrointestinal bleeds, and dermatologic were also analyzed.

**Conclusions:** The Johns Hopkins HHT Center of Excellence has a history of providing high quality multidisciplinary care to patients with HHT; however, its benefits to our practice and institution are not often highlighted. Our center of excellence has provided robust referrals to multiple departments while only requiring initial capital investment for a dedicated nurse coordinator, which is paid for by PAVM screening and treatment alone year to year.

### Procedure-specific complexity factors based on dose metric distributions for CT-guided interventional procedures

**K. Yang, S. Ganguli, M. DeLorenzo, H. Zheng, X. Li, B. Liu; Massachusetts General Hospital/Harvard Medical School, Boston, MA; Massachusetts General Hospital, Boston, MA**

**Purpose:** To present procedure-specific dose metric distributions and propose the creation of quantitative complexity factors (CF) for CT-guided interventional (CTGI) procedures.

**Materials:** With IRB approval and informed consent waived, this single-center HIPAA-compliant retrospective study collected dictation reports and radiation dose data from 9143 consecutive CTGI procedures on adult patients from 2012-2017. All cases were sorted into four major interventional categories: ablation, aspiration, biopsy, and drainage; each of which was further divided into sub-categories. After exclusion, a total of 8213 cases (4391 men and 3822 women) were divided into 21 sub-categories. Distributions of dose metrics were analyzed by category with descriptive statistic outcomes. The Spearman’s rank-order correlation was tested for the correlations between rankings by each metric. Quantitative CFs for each interventional sub-category were derived using median dose-length-product (DLP) as the reference.

**Results:** Wide variations of dose metrics were observed among sub-categories, even within the same major category. CT-guided ablations and drainages with multiple drains had higher median DLPs than aspirations and biopsies. Ranking by DLP mostly correlated to scan length ($p = 0.8039$, $p = 0.000013$) and least correlated to CTDI$\text{vol}$ ($p = -0.0883$, $p = 0.7029$). With a range of 1-4.9, CTGI subcategory CFs created via median DLP were shown to be correlative of specific procedure complexity. Three different levels of complexities were assigned to all CTGI sub-categories.

**Conclusions:** With a large number of cases analyzed and detailed categorization of CTGI procedures, procedure-specific quantitative CFs are provided using consistent dose metric distribution data.

### A snapshot of carotid artery stenting current practice: Intersocietal Accreditation Commission (IAC)-accredited facilities vs. non-accredited facilities

**M. Farrell, N. Merrill, M. Lally, B. Katzen, D. Sacks; Intersocietal Accreditation Commission, Ellicott City, MD; IAC, Ellicott City, MD; Miami Cardiac & Vascular Institute, Miami, FL; The Reading Hospital and Medical Center, Reading, PA**

**Purpose:** To ascertain differences in carotid artery stenting (CAS) practice between IAC accredited and non-accredited facilities.

**Materials:** An electronic survey was sent to 264 CAS facilities from a random sample of Centers for Medicare and Medicaid Services (CMS) certified facilities (N = 152), all CREST-2 participating facilities (N = 106), and all currently accredited IAC facilities (N = 6). The survey consisted of 16 measures of a CAS procedure considered to be best practice. The percentage of facilities following each measure was calculated. The number of measures per facility was summed and averaged to create an overall score.

**Results:** A total of 40 responses (17%) were received. Significant differences were found between the 3 groups for 5 of 16 measures: performing MRS prior to stenting ($p = .01$), accurately measuring percent stenosis using electronic calipers ($p = .01$), assessing patients for stroke and death at 30-day follow-up ($p = .03$), comparing outcomes to accepted benchmarks ($p = .03$) and participating in registries ($p = .01$). Overall, IAC facilities employed more of best practices (97% ± 5%) followed by CREST-2 facilities (73% ± 18%) and CMS facilities (66% ± 24%) ($p = .02$).

**Conclusions:** This study shows significant differences between IAC, CREST-2 and CMS facilities. Many CMS certified sites fail to perform essential best practices such as measuring stroke and death which are critical to determining satisfactory patient outcomes of CAS procedures.
Creation of an optimization process in a quaternary care academic institution leads to significant radiation dose reduction

A. Kalra-Lall, K. Wunderle, N. Obuchowski, M. Sands, R. Koerber, C. Martin; 1Case Western Reserve University School of Medicine, Cleveland, OH; 2Cleveland Clinic Foundation, Beachwood, OH; 3Cleveland Clinic, Cleveland, OH; 4N/A, Moreland Hills, OH; 5Cleveland Clinic Foundation, Cleveland, OH; 6The Cleveland Clinic Foundation, Pepper Pike, OH

Purpose: Here we discuss an initiative to optimize the radiation dose delivered to our patients while addressing the physician need for clinically acceptable image quality during interventional radiology (IR) procedures.

Materials: For this multioperator study, a team was assembled consisting of a staff physician, medical physicist, IR technologist, and specialist from a fluoroscope manufacturer to evaluate image acquisition and processing parameters for optimization. Radiation dose alterations were made through changing acquisition mode settings and, to a lesser extent, fluoroscopic mode parameters. These changes were made in an iterative process, using phantom data after each revision to analyze the dose curves and to validate setting changes prior to patient use. To observe real-time results, technical experts were available to make modifications during procedures.

Results: The study included data from 1193 preoptimization procedures and 1319 postoptimization procedures, which were inclusive of all procedure types performed using this manufacturer’s fluoroscopic system. The mean preoptimization reference plane air kerma was 423.6 mGy/case, and the mean air kerma rate (total air kerma divided by fluoroscopy beam time) was 91.8 mGy/min. The mean postoptimization air kerma was 287.1 mGy/case, and the mean air kerma rate was 59.2 mGy/min. These results represent a 32.2% decrease in the average air kerma and a 35.5% decrease in the average air kerma rate (both p-values < 0.001). Acceptable image quality was maintained while significantly decreasing these radiation dose surrogate parameters.

Conclusions: Through engaging key stakeholders and evaluating current practice we were able to identify opportunities for protocol optimization resulting in significant patient radiation dose reduction.

Dose in Study Patients Before and After Optimization

<table>
<thead>
<tr>
<th>Measure</th>
<th>CMS, % (n = 22)</th>
<th>CREST-2, % (n = 12)</th>
<th>IAC, % (n = 6)</th>
<th>Total</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSS prior</td>
<td>77.3</td>
<td>80.0</td>
<td>100</td>
<td>81.1</td>
<td>.32</td>
</tr>
<tr>
<td>MRS prior</td>
<td>36.4</td>
<td>40.0</td>
<td>100</td>
<td>51.4</td>
<td>.01</td>
</tr>
<tr>
<td>DSA prior</td>
<td>77.3</td>
<td>50.0</td>
<td>80.0</td>
<td>70.3</td>
<td>.28</td>
</tr>
<tr>
<td>% Stenosis electronic caliper</td>
<td>31.8</td>
<td>40.0</td>
<td>100</td>
<td>43.2</td>
<td>.01</td>
</tr>
<tr>
<td>ACT &gt; 250 sec</td>
<td>54.5</td>
<td>70.0</td>
<td>100</td>
<td>64.9</td>
<td>.06</td>
</tr>
<tr>
<td>Tx antiplatelet dual regimen</td>
<td>81.8</td>
<td>80.0</td>
<td>80.0</td>
<td>81.1</td>
<td>.99</td>
</tr>
<tr>
<td>Measure NASCET</td>
<td>68.2</td>
<td>80.0</td>
<td>100</td>
<td>75.7</td>
<td>.17</td>
</tr>
<tr>
<td>Embolic device</td>
<td>90.9</td>
<td>90.0</td>
<td>100</td>
<td>91.9</td>
<td>.63</td>
</tr>
<tr>
<td>DSA post</td>
<td>72.7</td>
<td>40.0</td>
<td>80.0</td>
<td>64.9</td>
<td>.16</td>
</tr>
<tr>
<td>NIHSS 24 hr post</td>
<td>77.3</td>
<td>80.0</td>
<td>100</td>
<td>81.1</td>
<td>.32</td>
</tr>
<tr>
<td>30-day f/u NIHSS</td>
<td>82.4</td>
<td>83.3</td>
<td>100</td>
<td>85.7</td>
<td>.36</td>
</tr>
<tr>
<td>30-day f/u MRS</td>
<td>82.4</td>
<td>91.7</td>
<td>100</td>
<td>88.6</td>
<td>.34</td>
</tr>
<tr>
<td>30-day outcomes stroke and death</td>
<td>72.7</td>
<td>100</td>
<td>100</td>
<td>83.8</td>
<td>.03</td>
</tr>
<tr>
<td>~30-day noninvasive study</td>
<td>59.1</td>
<td>60.0</td>
<td>100</td>
<td>64.9</td>
<td>.09</td>
</tr>
<tr>
<td>Benchmark stroke d death</td>
<td>50.0</td>
<td>40.0</td>
<td>100</td>
<td>54.1</td>
<td>.03</td>
</tr>
<tr>
<td>Participate in registries</td>
<td>63.6</td>
<td>100</td>
<td>100</td>
<td>80.0</td>
<td>.01</td>
</tr>
<tr>
<td>Overall (mean)</td>
<td>66.0</td>
<td>72.9</td>
<td>96.5</td>
<td>72.0</td>
<td>.02</td>
</tr>
</tbody>
</table>

*From the fitted models, with adjustment for procedure dose.

Beyond the MDRD equation: kinetic estimates of GFR in acutely ill patients

M. Gusman, S. Veazey, D. Luellen, J. Sosnov; 1San Antonio Military Medical Center, San Antonio, TX; 2United States Army Institute for Surgical Research, Fort Sam Houston, TX

Purpose: Provide a tool that simplifies decisions on the appropriateness of contrast administration in patients developing or healing from acute kidney injury.

Materials: The kinetic estimated GFR (KeGFR) equation is utilized by nephrologists in the care of patients with rapidly changing creatinine (Cr). The concept of this equation is that plasma Cr can only increase by a finite amount each day as a function of muscle
mass—a common estimate of this maximum is 1.5 mg/dL. We developed a calculator which automates these calculations and displays both the typically used MDRD eGFR and the keGFR, along with a graph of the trends.

**Results:** Our calculator was validated on a subset of 20 inpatients and matches the keGFR and MDRD eGFR.

**Conclusions:** Faced with a patient with unstable Cr, radiologists review prior lab data to gain a sense of the Cr trend and/or compare to the patient’s baseline. There are no guidelines for this subjective assessment. The keGFR equation identifies AKI patients earlier than the typically used MDRD eGFR. Although the approach of substituting keGFR for eGFR is not yet validated, the keGFR equation distills the back-of-the-envelope calculations that we are presently doing and yields a product worthy of further study. We recommend that future investigations of the epidemiology and pathophysiology of contrast complications move toward kinetic estimates of GFR when assessing inpatient renal function. Our calculator can support such work.

### Example Patient

<table>
<thead>
<tr>
<th>Time Since Admission (hr)</th>
<th>Plasma Cr (mg/dL)</th>
<th>MDRD eGFR (mL/min/1.73m²)</th>
<th>keGFR (mL/min/1.73m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.8</td>
<td>129.8</td>
<td>129.8</td>
</tr>
<tr>
<td>12</td>
<td>1.55</td>
<td>60.5</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>2.3</td>
<td>38.4</td>
<td>0</td>
</tr>
<tr>
<td>36</td>
<td>2.7</td>
<td>31.9</td>
<td>19.4</td>
</tr>
<tr>
<td>48</td>
<td>2.5</td>
<td>34.8</td>
<td>50.6</td>
</tr>
<tr>
<td>60</td>
<td>2.2</td>
<td>40.4</td>
<td>61.9</td>
</tr>
<tr>
<td>72</td>
<td>1.8</td>
<td>50.9</td>
<td>78.6</td>
</tr>
<tr>
<td>84</td>
<td>1.4</td>
<td>68</td>
<td>99.5</td>
</tr>
</tbody>
</table>

The 12- and 24-hour eGFR values suggest some preserved renal function. In fact, the GFR is close to zero at 12 and 24 hours; only complete absence of filtration can explain such a steep climb in Cr. Conversely, the keGFR equation suggests more rapid improvement in renal function as Cr declines.

---

**Readability of patient education materials from RadiologyInfo.org: has there been progress over the past 5 years?**

E. Huh¹, P. Yi¹, F. Hui²; ¹Johns Hopkins, Baltimore, MD; ²Johns Hopkins Hospital, Baltimore, MD

**Purpose:** As patients increasingly turn to the Internet for healthcare information, it is imperative that patient educational materials are written at an appropriate readability level. Although RadiologyInfo.org, a patient education library sponsored by the American College of Radiology (ACR) and Radiological Society of North America, was shown in 2012 to be written at levels too high for the average patient to adequately comprehend, it is unclear if there has been progress made in the past 5 years. The purpose of this study was to provide a 5-year update on the readability of patient educational materials from RadiologyInfo.org.

**Materials:** All patient education articles available in 2017 from the ACR and RSNA-sponsored RadiologyInfo.org patient education library were reviewed. We assessed each article for readability using 6 quantitative readability scales: the Flesch-Kincaid (FK) grade level, Flesch Reading Ease, Gunning-Fog Index, Coleman-Liau Index, Automated Readability Index, and the Simple Measure of Gobbledygook (SMOG). The number of articles with readability ≤ the 8th-grade level (average reading ability of US adults) and the 6th-grade level (NIH-recommended level for patient education materials) were determined.

**Results:** 131 patient education articles were reviewed. The mean readability grade level was greater than the 11th grade reading level for all readability scales. None of the articles were written at less than the 8th-grade or the 6th-grade levels.

**Conclusions:** Although there has been an increasing awareness of the issue of readability of patient educational materials within the radiological community, the patient educational materials from the ACR and RSNA-sponsored RadiologyInfo.org website are still written at levels too high for the average patient. Future efforts should be made to improve the readability of these patient education materials.

---

**Radioembolization for hepatocellular carcinoma patients with portal vein thrombosis: a single-center 14-year experience**

N. Abouchaleh¹, A. Gabr², R. Ali³, R. Mora⁴, A. Al Asadi⁵, S. Mouli², A. Riaz⁵, R. Lewandowski⁶, R. Salem⁷; ¹Northwestern University, Chicago, IL; ²Northwestern University Feinberg School of Medicine, Chicago, IL; ³Northwestern University, Forest Park, IL; ⁴N/A, Chicago, IL; ⁵Northwestern Medicine, Chicago, IL

**Purpose:** To report overall survival (OS) outcomes for advanced stage hepatocellular carcinoma (HCC) with portal vein thrombosis (PVT) treated with yttrium-90 radioembolization (Y90).

**Materials:** With IRB approval we searched our prospectively acquired database for patients treated with Y90. Patients who had advanced stage HCC with tumor PVT were included. Patients who had simultaneous hepatic vein invasion and extrahepatic metastases were excluded. Clinical and laboratory data were collected at baseline and 1 month post-Y90. Toxicity was assessed using CTCAE v4.0. OS outcomes were reported and stratified by Child-Pugh (CP) and location of PVT. OS was calculated using Kaplan Meier method. Multivariate analysis was conducted using
Cox-proportional hazards. A subanalysis for patients with high alpha-fetoprotein (AFP) (>100 ng/dL) was conducted.

**Results:** 185 patients with HCC and tumor PVT had Y90. 43(23%) patients had segmental, 65(35%) had lobar, and 77(42%) had main PVT. 74 patients (40%) were CPA, 51(28%) were CPB7 and 60(32%) were CP ≥ B8. New grade 3/4 toxicities were seen in 29(16%) patients for bilirubin, 23(13%) for albumin, and 5(2.6%) for alkaline phosphatase. Median OS(months) (95% CI) for CPA, CPB7, and CP ≥ B8 patients was 13.3(8.7-15.7), 6.9(5.3-10.1), and 3.9(2.9-5.0), respectively. For CPA patients, median OS(months) (95% CI) was 14.3(12.0-17.8) for segmental, 14.2(7.3-19.5) for lobar and 7.7(4.6-13.8) for main [P = 0.78]. For CPB7 patients, median OS (months) (95% CI) was 6.5(3.4-38) for segmental, 6.9(4.6-13.3) for lobar and 7.7(4.8-11.1) for main [P = 0.82]. For CP ≥ B8 patients, median OS (months) (95% CI) was 8.4(1.2-75.2) for segmental, 4.4(2.5-9.7) for lobar and 3.4(2.5-4.6) for main [P = 0.015]. Multivariate analysis showed baseline bilirubin, ascites, and AFP to be significant OS prognosticators. Out of 123 patients with high AFP, 12(10%) patients normalized their AFP levels (<13) with a median OS of 23.9 months (CI:20.1-124.1).

**Conclusions:** Y90 can serve as a safe and effective treatment for advanced HCC patients with tumor PVT, particularly for those with preserved liver function. OS is affected by baseline liver function, tumor size, and AFP level. Location of PVT had a significant effect on OS in CP ≥ B8.

---

**Resin vs glass radioembolization: a comparison of survival in patients treated for hepatocellular carcinoma with portal vein thrombosis**

H. Walton, F. Chou, B. Maher, D. Klass, D. Liu, J. Chung; University of British Columbia, Vancouver, BC

**Purpose:** To compare the survival of patients treated with glass vs resin Yttrium-90 (Y-90) selective internal radiation therapy (SIRT) for hepatocellular carcinoma (HCC) with portal vein thrombosis (PVT).

**Materials:** We included all patients treated with Y-90 SIRT for HCC with PVT over a 5 year and 1-month period (18th July 2011 to 9th August 2017). Data was retrospectively collected for survival (days to death or days to last clinical review), Y-90 SIRT carrier-type, Child-Pugh score, age and gender. Categorical variables were analyzed using the Chi-squared test. Continuous variables were analyzed using the Mann-Whitney test. Kaplan-Meier survival curves were used to analyze differences in survival using the Gehan-Breslow-Wilcoxon test. We also recorded whether the patient had whole liver, lobar or segmental SIRT and whether treatment was given in one session or two. Dosimetry was calculated utilizing single compartment MIRD for glass, and partition model for resin.

**Results:** 78 patients satisfied the inclusion criteria. 60 were treated with glass (77%) and 18 were treated with resin (23%). Of those treated with resin SIRT 14 patients were treated with whole liver SIRT; 2 were treated with segmental SIRT; 2 were treated with lobar SIRT. Of those treated with glass, 51 patients were treated with whole liver SIRT; 6 were treated with segmental SIRT; 3 were treated with lobar SIRT. There were no significant differences in Child-Pugh score, age and gender between the two groups (p>0.05). All patients underwent single session SIRT. Median survival by Kaplan-Meier analysis was 171 days for glass and 220 days for resin. Of the patients who died during follow-up, the range of overall survival was 13-1289 days for glass and 26-220 days for resin. There was no significant difference in the survival curves of two groups (p = 0.66). There were no major complications in either group. Results are ongoing.

**Conclusions:** Our findings show no statistically significant difference in survival for patients treated with glass vs resin for Y-90 SIRT in patients with HCC with PVT.

---

**Radiation segmentectomy vs. radiofrequency ablation in early stage hepatocellular carcinoma**

A. Gabr, R. Ali, R. Mora, K. Sato, K. Desai; Northwestern University Feinberg School of Medicine, Chicago, IL; Northwestern University, Chicago, IL; 3Northwestern University, Forest Park, IL; 4N/A, Chicago, IL; 5Northwestern Medicine, Chicago, IL

**Purpose:** Radiofrequency ablation (RFA) is considered curative for early stage hepatocellular carcinoma (HCC). Yttrium-90 radiation segmentectomy (RS) involves high-dose segmental delivery of radioactive microspheres. In this study, we compare overall survival (OS) of RFA vs. RS for patients with early stage HCC and preserved liver function.

**Materials:** An IRB-approved and HIPAA compliant chart review of HCC patients treated with RFA (Cool-Tip, Medtronic, Minneapolis, MN) or RS (Therasphere, BTG, West Conshohocken, PA) between (2004-2017) was performed. Inclusion criteria were: a) solitary HCC (≤3 cm), b) with no macrovascular invasion or extrhepatic metastases and c) preserved liver function [Child-Pugh (CP) A]. RS was performed instead of RFA if the tumor was in close proximity to large vessels, >40% of the surface of the tumor was abutting the liver capsule, or the tumor was in a percutaneously inaccessible location. Patients who underwent subsequent liver directed therapy (including transplantation and resection) were excluded. Baseline characteristics were compared using independent t-test. OS was calculated using Kaplan-Meier method from date of first treatment and compared using log-rank test. Data are presented as medians with 95% confidence interval (CI), with a p<0.05 considered significant.

**Results:** 25 patients treated with RFA were compared to 45 patients treated with RS. There was no significant difference in baseline characteristics for RFA and RS, respectively: age 67 and 68 years, respectively (P = 0.28); serum albumin 3.8 g/dL (3.5-4.0) and 3.5 g/dL (3.3-3.6), respectively (P = 0.03); serum bilirubin 1 mg/dL (0.8-1.3) and 0.8 mg/dL (0.7-0.9), respectively (P = 0.06); and tumor size 1.8 cm (1.5-2) and 2.2 cm (2.1-2.4), respectively (P = 0.0002). The median OS (95% CI) for RFA cohort was 49.2 months (29-73.5), while it was not reached for RS cohort at 104 months follow-up. 5-year survival rate was 45% for RFA and 75% for RS (P = 0.1).

**Conclusions:** RS for early stage HCC ≤3cm and preserved liver function demonstrates a trend towards improved OS compared to...
RFA. Our data suggests curative potential of RS in early stage HCC that will be the focus of future prospective studies.

3:27 PM  
Abstract No. 84

Radiation segmentectomy vs. conventional Y-90 selective internal radiation therapy: a comparison of survival in patients treated for hepatocellular carcinoma with portal vein thrombosis

H. Walton1, D. Liu3, F. Chou1, D. Klass1, B. Maher1, J. Chung3; 1University of British Columbia, Vancouver, BC

Purpose: To compare the survival of patients treated with radiation segmentectomy vs. conventional Y-90 selective internal radiation therapy (SIRT) for hepatocellular carcinoma (HCC) with portal vein thrombosis (PVT) on an intent to treat basis.

Materials: All patients treated with Y-90 SIRT for HCC with PVT over a 5-year and 1-month period (18 July 2011 to 9th August 2017) were reviewed. Categorical variables (dosimetric approach, glass vs resin, Child Pugh score and demographics) were retrospectively analyzed using the Chi-squared test. Continuous variables were analyzed using the Mann-Whitney test. Kaplan-Meier survival curves were used to analyze differences in survival between the two groups. The Kaplan-Meier survival curves were statistically compared using the Gehan-Breslow-Wilcoxon test.

MIRD based dosimetry was applied for glass, and partition based dosimetry for resin.

Results: 78 patients satisfied the inclusion criteria. 67 patients underwent conventional SIRT technique (86%) and 11 were treated with radiation segmentectomy (14%). 52 conventional SIRT patients were treated with glass and 15 were treated with resin. 8 Radiation segmentectomy patients were treated with glass and 3 were treated with resin. All patients underwent single session SIRT. There were no significant differences in the patient groups regarding age, gender, Child-Pugh score or radioembolic. Median survival by Kaplan-Meier analysis was 1289 days for radiation segmentectomy and 171 for conventional SIRT. Of the patients who died during follow-up, the range of overall survival was 35-1289 days for radiation segmentectomy and 13-894 days for conventional SIRT. Patients treated by radiation segmentectomy had a significantly better survival than the patients treated with conventional SIRT (p = 0.0062). There were no radiation related complications. Results are ongoing.

Conclusions: This study demonstrates the safety and effectiveness of radiation segmentectomy as a treatment for HCC with PVT utilizing either glass or resin SIRT. Furthermore, survival analysis demonstrates a significant increase in overall survival for patients treated with radiation segmentectomy compared to those treated with conventional SIRT.

3:36 PM  
Abstract No. 85

Pretreatment 99mTc-mebrofenin hepatobiliary scintigraphy, an adjuvant predictor of post-radioembolization clinical status

S. Chowdhury1, M. Ertreo1, J. An2, G. Lynskey1, T. Cardi1, E. Cohen1, J. Cardella1, D. Field1, D. Buckley1, J. Spies1, A. Kim1; 1Medstar Georgetown University Hospital, Washington, DC; 2National Institutes of Health, Bethesda, MD

Purpose: To correlate scintigraphic hepatobiliary 99mTc-mebrofenin uptake ratio prior to 90Y-radioembolization (RE) with post-RE clinical status and liver function.

Materials: A single-center retrospective review was performed of patients with hepatobiliary 99mTc-mebrofenin scan prior to RE for primary or secondary liver malignancy from July 2015 to September 2017. Regions of interest for mebrofenin uptake were drawn over the entire image, heart and liver. Corrected mebrofenin uptake ratio (cMUR) was calculated as %uptake/min/BSA (body surface area). Pre-RE and 2-month post-RE albumin, total bilirubin, ECOG, MELD, ALBI, and Child-Pugh (CP) scores were compared using Wilcoxon rank sum test for continuous variables and Fisher’s exact test for categorical variables. Pre-RE cMUR was correlated with the 2-month post-RE measures of liver function using the Spearman’s rank correlation test. Significance was considered at p < 0.05. Results are presented as median and interquartile range.

Results: Twenty-two patients were included. Eleven (50%) patients had hepatocellular carcinoma, the remaining metastatic disease. 6 (30%) patients had cirrhosis. Pre-RE cMUR was 6.32% uptake/min/m² (5.04-8.33). Total delivered activity and dose were 36.87 mCi (17.11-46.29) and 53.82 Gy (34.82-81.63), respectively. At 2-month follow-up, albumin decrease (3.1 vs. 3.55 g/dL, p = 0.03), CP (6.5 vs. 6, p = 0.028) and ALBI scores (-1.79 vs. -2.375, p = 0.009) worsening from pre-RE values were the only statistically significant changes. Pre-RE cMUR demonstrated significant negative correlation with post-RE CP (p = 0.0091) and ALBI scores (p = 0.0365). Total delivered activity and dose showed no significant correlation.

Conclusions: Pre-RE cMUR was an effective predictor of post-RE CP and ALBI scores, suggesting possible use of cMUR as a surrogate marker for selecting ideal RE candidates. The results may have been limited by sample size, however, this study provides preliminary evidence to support further exploration of this relationship in future studies.

3:45 PM  
Abstract No. 86

Improved post-transplant outcomes in patients achieving pathological necrosis following radioembolization of hepatocellular carcinoma

A. Gabr1, R. Ali2, R. Mora3, A. Al Asadi3, N. Abouchaleh4, K. Desai4, B. Thornburg5, S. Mouli5, A. Riaz6, R. Lewandowski6, R. Salem7; 1Northwestern University Feinberg School of Medicine, Chicago, IL; 2Northwestern University, Forest Park, IL; 3N/A, Chicago, IL; 4Northwestern University, Chicago, IL; 5Northwestern Memorial Hospital, Chicago, IL; 6Northwestern Medicine, Chicago, IL

Purpose: To evaluate the impact of post-Y90 radioembolization (Y90) pathological necrosis in hepatocellular carcinoma (HCC) on overall survival (OS) and recurrence free survival (RFS) following liver transplantation (LT).

Materials: In this IRB approved study, 170 consecutive HCC patients underwent LT after bridging/downstaging by Y90 between
2004 and 2017. On the date of LT, pathologic analysis of the explants was performed. Necrosis was reported as complete (CN) (no viable HCC), extensive (EN) (50-99% necrosis) and partial necrosis (<50%). Recurrence-free survival (RFS) and overall survival (OS) were calculated using Kaplan-Meier Method from date of LT. Log-rank test was used to compare the OS and RFS of between CN, EN and PN.

**Results:** 170 patients underwent LT after Y90, with a median time to LT of 7.4 months (IQR: 4.4-10.3). Three-month mortality rate after LT was 6/170 (3.5%). 75 (44%), 49 (29%) and 46 (27%) patients showed CN, EN, and PN on explant pathologic assessment. Three, five, and ten-year OS rates were 86%, 80%, and 56% respectively. 20 patients developed recurrence, with 3, 5 and 10-year RFS rates of 79%, 67% and 40%. Median RFS was 119 (95% CI: 68-119) months. There was a significant difference in the number of recurrences and RFS between patients who had CN or EN vs. patients who had PN [p<0.0001]. Recurrence was seen in 2/75 (3%) patients with CN, 4/49 (8%) patients with EN, and 14/46 (30%) patients with PN [(Chi-squared = 22.04) [p<0.0001]]. Median time to recurrence in patients who had PN was 58 months (95%CI 37-58), while it was not reached at 10 years for patients who had CN or EN [p<0.0001]. There was no statistically significant difference in OS of patients who had CN, EN, or PN [p = 0.39]. However, pathological response to treatment showed statistically significant improvement in RFS [p = 0.03].

**Conclusions:** LT after Y90 represents a curative treatment for HCC with excellent OS rates comparable to LT for non-malignant causes. Patients who achieved EN or CN have improved RFS compared to patients with PN.

---

**Factors affecting local tumor progression after yttrium-90 radiation segmentectomy for hepatocellular carcinoma**

**D. Shin**<sup>1</sup>, G. Johnson<sup>1</sup>, W. Monsky<sup>2</sup>, D. Hippe<sup>1</sup>, S. Padia<sup>3</sup>; <sup>1</sup>University of Washington, Seattle, WA; <sup>2</sup>University of Washington Medical Center, Seattle, WA; <sup>3</sup>University of California, Los Angeles, Santa Monica, CA

**Purpose:** Yttrium-90 (Y90) radiation segmentectomy has been shown to yield high response rates with low rates of subsequent local tumor progression for localized hepatocellular carcinoma (HCC). This study assessed factors associated with increased rates of local tumor progression after segmental radioembolization for HCC.

**Materials:** In this retrospective study, 101 patients with 132 tumors underwent segmental Y90 radioembolization, with a previously reported mRECIST complete response rate of 92% and objective response rate of 98%. Baseline Child-Pugh score and alpha-fetoprotein level, tumor characteristics (size, infiltrative growth pattern, portal venous invasion), and treatment parameter (delivered Y90 dose) were incorporated in a cause-effect analysis to determine which factors were associated with local tumor progression within 2 years of treatment. Death and liver transplant were considered as competing risks for the regression analysis model.

**Results:** Patients were followed to 2 years after the radioembolization. Eleven (8%) of the 132 treated tumors demonstrated local progression during the follow-up period. Six patients underwent liver transplantation, and 15 died. Local tumor progression was most strongly associated with baseline tumor size (0% for tumors ≤3 cm vs. 22% for >3 cm, p=0.041). Child-Pugh score, infiltrative growth pattern, vascular invasion, and delivered Y90 dose did not reach statistical significance with regards to association with local tumor progression.

**Conclusions:** For localized HCC, segmental Y90 radioembolization shows high efficacy and prolonged local tumor control despite various patient, tumor, and treatment factors. Tumor size is the factor most strongly associated with local tumor progression, with curative rates for tumors ≤3 cm at 2 years.

---

**Retrospective analysis of second-line Y-90 compared to 1st line Y-90 in patients with nonresectable hepatocellular carcinoma**

**A. Reposar**<sup>1</sup>, N. Hoang<sup>2</sup>, M. Khalaf<sup>1</sup>, M. AbdelRazek<sup>1</sup>, D. Katz<sup>2</sup>, D. Wang<sup>3</sup>, J. Louie<sup>2</sup>, D. Sze<sup>1</sup>; <sup>1</sup>Stanford University Medical Center, Stanford, CA; <sup>2</sup>Stanford University, Stanford, CA; <sup>3</sup>Stanford University School of Medicine, Stanford, CA

**Purpose:** Yttrium-90 radioembolization (RE) is an effective treatment for hepatocellular carcinoma (HCC), but is often reserved for more advanced disease due to logistical issues. This study retrospectively examined the outcomes of RE when used as 1st line therapy vs 2nd line therapy after failure of transarterial chemoembolization (TACE).

**Materials:** 219 patients undergoing 1st or 2nd line RE for HCC from November 2006 to June 2017 were reviewed. All patients were originally eligible for both RE and TACE. First line RE was preferred for patients outside of UCSF criteria (e.g. large tumor burden, infiltrative disease, vascular invasion), for whom insurance predetermination was secured and hepatopulmonary shunting was within acceptable limits. 2nd line RE was performed on patients who failed TACE. Radiographic response was assessed using mRECIST criteria. Adverse events were tabulated; time to progression (TTP), progression-free survival (PFS), and overall survival (OS) were calculated from time of initial embolotherapy and from time of RE.

**Results:** The 1st line group was comprised of 136 patients (111 male, 25 female). The 2nd line group of 83 patients (68 male, 15 female) underwent a median of 2 TACE procedures prior to RE. The median age of both groups was 64. The 1st line group received higher Y90 activity (3.39 vs 2.68 GBq, p = .002). The 2nd line group showed significantly worse radiographic response (P = .016) with a higher proportion of PD at 3 months (63% vs 47%, P = .033). Any toxicity of CTCAE grade ≥3 occurred in 37% of the 1st line group and 30% of the 2nd line group (NS). From time of RE, the OS (11.8 vs 10.9 mos, P = NS), TTP (5.4 vs 4.2 mos, P = NS), and PFS (4.5 vs 3.5 mos, P = .076) trended higher in the 1st line group. From the time of initial embolotherapy, the OS and TTP in the 2nd line group were 19.0 and 6.5 mos, respectively.

**Conclusions:** Second-line RE for HCC after failure of TACE showed slightly inferior radiographic response but similar survival outcomes when compared to first-line treatment of other later stage disease. Prior failure of TACE is not a contraindication for RE.
Long-term survival outcomes of early stage HCC undergoing Y90 radiation segmentectomy


Purpose: This study aims to assess long-term survival outcomes of ablative segmental radioembolization with yttrium-90 (radiation segmentectomy (RS)) for early stage hepatocellular carcinoma (HCC).

Materials: With IRB approval, we included patients from our prospectively acquired database that were treated with RS for HCC between 2004-2017. Intention to treat (ITT) overall survival (OS) was estimated using Kaplan Meier method from date of treatment. Censored OS was estimated by censoring patients who underwent curative liver transplantation or resection. Further OS sub-analysis was done on patients with HCC ≤ 3 cm.

Results: 269 patients met the inclusion criteria. 66% (n = 177) were males and mean age was 66 years (range, 22-96). At baseline, 51% (n = 136) were Child-Pugh (CP) A, 43% (n = 115) CP B, and 7% (n = 18) CP C. According to UNOS tumor staging, 14% (n = 37) patients had T1 tumors, 79% (n = 212) had T2, and 7% (n = 20) had T3 tumors. 38% (n = 103) of patients were bridged to liver transplant. 4% (n = 10) had surgical resection after RS. 8.5% (n = 23) developed new grade 3/4 bilirubin toxicity, and 1.5% (n = 4) developed new grade 3 albumin toxicity. Censored OS was 80.3 (CI: 44-80.3) months for CP A and 27 (CI:17–31) months for CP B. ITT OS was 102 (CI: 80.3-120) months for CP A and 39 (CI:29-82.5) months for CP B patients. Further stratification for CP A by size demonstrated survival difference by tumor size ≤3 cm vs >3 cm, with median censored OS of 80 (CI: 44:80.3) and 47 (CI: 29.3:61) months, respectively (p = 0.05). For this (≤3 cm) select cohort (n = 87), 1-,3- and 5-year survival rates was 99%, 79%, 69% respectively. On multivariate analysis baseline albumin, and AFP > 100 ng/dl were significant prognosticators of survival.

Conclusions: Radiation segmentectomy is a safe and effective treatment for patients with early stage HCC. Patients with CP A liver function and HCC ≤3 cm exhibit survival outcomes similar to other curative surgical and ablative treatments.

Purpose: To evaluate predictive factors of 90-day mortality in patients with hepatic metastatic disease undergoing Y90 radioembolization (RE).

Materials: Single-institution retrospective review of 295 SIR-spheres treatments from October 2009 – April 2017. Exclusion of patients with hepatocellular carcinoma and lack of available oncologic history yielded 182 treatments in 155 patients. Baseline patient characteristics, laboratory values (INR, Platelets, AST, ALT, Total Bilirubin, Alkaline Phosphatase, and Creatinine), prior therapies (chemotherapy, hepatic locoregional therapy, hepatic surgery), other oncologic history (date of diagnosis, extrahepatic metastases, other malignancy) and Y90 treatment parameters (hepatopulmonary shunt, hepatic tumor volume, dose (GBq), unilobar vs bilobar treatment) were recorded. For univariate and multivariate comparative analysis, patients were divided into two groups-those who died within 90 days and those who did not.

Results: All cause 90-day mortality following treatment was 16.5% (n = 30). The study groups were not significantly different in regard to type of malignancy (metastatic colorectal, metastatic neuroendocrine, other metastatic disease, and cholangiocarcinoma, p = 0.145), age at time of diagnosis (p = 0.422), or age at treatment (p = 0.223). Gender proportions were significantly different among the two groups (70% male (n = 106) vs 41% male (n = 12), p = 0.005). On univariate analysis, alkaline phosphatase (p = 0.002), total bilirubin (p = 0.007), AST (p = 0.025), and single lobe vs bilobar treatment (p = 0.0003) differed significantly between the two groups. After controlling for type of malignancy, total radioembolization dose, and gender proportions, alkaline phosphatase (OR = 4.33, 95% CI = 1.62-11.57, p = 0.003), total bilirubin (OR = 4.05, 95% CI = 1.50-10.97, p = 0.006), and AST (OR = 2.50, 95%CI = 1.06-5.73, p = 0.037) remained significant.

Conclusions: In patients with hepatic metastases undergoing SIR-spheres RE, hepatic function tests were the only significant predictive factors of 90-day mortality in multi- and univariate analysis. Seemingly minor alterations in these lab values may represent underlying disease characteristics that impact mortality.
Purpose: Percutaneous renal biopsies are commonly performed minimally invasive interventions to determine etiologies of renal failure and characterize focal renal lesions. Data regarding utilization and outcomes for these procedures are generally limited to retrospective series from high volume centers. The purpose of this study was to establish population-based measurements for percutaneous renal biopsy procedure complications and their risk factors.

Materials: Using administrative data from all inpatient and outpatient hospital encounters in California (2009-2011), patients undergoing percutaneous renal biopsies were identified. The demographic characteristics of this patient cohort as well as risk factors for complications were analyzed.

Results: 14,973 percutaneous renal biopsies were performed in 13,372 patients during the study period. Comorbidities included renal failure (35.1%), hypertension (58.8%), atherosclerosis (8.7%), diabetes (20.5%), obesity (10.0%), congestive heart failure (9.6%), coagulopathy (6.9%), and malignancy (11.7%). Biopsies were performed across 282 hospitals, with yearly procedural volumes ranging from 1 to 312.6. Of the 4,796 patients who underwent biopsies as outpatients, 183 patients (3.8%) had unscheduled hospital visits within 7 days of the procedure, with a median length of stay of 3 days (range, 0 - 68 days). Post-biopsy hemorrhage was identified in 6.1% of patients undergoing biopsy, and 1.8% of patients required blood transfusions within 30 days of the biopsy. The all cause 30-day inpatient mortality rate was 2.8%. History of renal failure (OR 1.03 [1.01 – 1.05]) and hypertension (OR 1.02 [1.00 -1.04]) were significantly associated with post-biopsy hemorrhage, and history of renal failure (OR 1.03 [1.01 – 1.04]), hypertension (OR 1.03 [1.02 – 1.05]), and diabetes (OR 1.02 [1.00 – 1.03]) were significantly associated with delayed hospitalization.

Conclusions: Percutaneous renal biopsies are a commonly performed procedure with low complication risks. These population estimates should help establish patient and physician expectations as well as societal guidelines for complication rate thresholds.

Impact of rapid onsite pathology evaluation (ROSE) on biopsy adequacy: a retrospective review of 610 image-guided biopsies
M. Philip1, J. Kelman1, S. Mouli1, R. Gupta1; 1Northwestern University Feinberg School of Medicine, Chicago, IL

Purpose: Rapid onsite evaluation (ROSE) for percutaneous biopsy is a system in which a cytopathologist is available at the time of procedure to evaluate sample adequacy. The aim of our study is to evaluate sample adequacy rates at two academic hospitals staffed by the same group of interventional radiologists, one which uses ROSE and one which does not. We hypothesize ROSE improves the rate of diagnostic specimens obtained and decreases both the number of needle passes and the need for repeat biopsy.

Materials: IRB approval was obtained at center 1 (with ROSE) and waived at center 2 (without ROSE) for this retrospective review of 610 liver, lung and thyroid biopsies. Center 1 included 96 thyroid, 110 liver, and 114 lung biopsies; center 2 included 117 thyroid, 60 liver, and 112 lung biopsies. The two groups were compared using the t-test and ANOVA for age and sex, respectively. Comparisons of the number of needle passes were done using least squares regression, adjusting for age, sex, and target site. Comparison of whether a specimen was diagnostic was done using a multivariate logistic regression model.

Results: After performing multivariate analysis adjusting for age, sex, and tissue type, the odds of having a diagnostic specimen were almost 4 times greater at center 1 than at center 2 (OR 3.97, p<0.01). The rebiopsy rate was significantly lower at center 1 when compared to center 2 (p<0.01). There was no significant difference in the number of needle passes taken per biopsy site when compared between the two centers.

Conclusions: ROSE improves the diagnostic yield of image-guided liver, lung, and thyroid biopsies. Our large study presents evidence that on-site cytopathology is a valuable resource; it improves the time to diagnosis by increasing the diagnostic yield at the time of procedure, and it decreases the need for rebiopsy. Thus, centers that utilize image-guided percutaneous biopsy should allocate resources to cover on-site cytopathologic evaluation.

Incidence of delayed chest tube placement in patients with a stable, small pneumothorax after lung biopsy
T. Connors1, S. McRae1, S. Huang1, K. Ahrar1, S. Gupta1, S. Sabir1; 1MD Anderson Cancer Center, Houston, TX

Purpose: To determine the incidence of delayed chest tube placement in patients with a stable, small pneumothorax after lung biopsy

Materials: Retrospective review of 501 consecutive patients undergoing outpatient CT-guided percutaneous lung biopsy (CTLB). Per departmental policy, single-view frontal chest x-rays (CXR) were obtained immediately and 3-hours post-biopsy. If PTX was discovered on routine CXR, a 1-hour follow-up CXR was additionally obtained. Patients with stable, small PTX were discharged after observation. Next-day CXR was ordered by the interventional radiologist who performed the CTLB. Demographics, procedure and imaging variables, and complications were collected.

Results: The average patient age was 66 years (15 – 93), 50.7% were female, and 17.4% had history of COPD. Median lesion size was 1.5 cm (0.5 – 10.0). Biopsy was performed with core in 98.2% and fine-needle aspiration in 54.5% of patients with a median 20-gauge (18 – 20) needle and 22-gauge needle, respectively. Biosentry™ tract sealant was used in 59.3% of cases. On the day of the biopsy, 104 patients (20.8%) developed PTX and 35 patients (7.0%) required chest tube. 69 patients (13.8%) were discharged with a stable, small PTX and 36/69 (52.2%) patients were scheduled for next-day CXR. Of patients returning for CXR, 32/36 (88.9%) required no intervention while 4/36 (11.1%) had an enlarging PTX needing chest tube placement. The 33/69 (47.8%) patients not returning for...
next-day CXR did not have a chest tube placed at our institution per the medical record; it is unknown if they needed a chest tube elsewhere.

**Conclusions:** Of patients discharged with a stable, small PTX after outpatient CTLB, 52.2% underwent next-day CXR and 11.1% of them required chest tube placement, demonstrating the appropriateness of next-day follow-up in patients with stable PTX after outpatient CTLB.

3:27 PM Abstract No. 94

**A prospective randomized study of autologous blood patch injection versus BioSentry hydrogel tract plug in image-guided percutaneous lung biopsy**

M. Maybody1, N. Muallem1, K. Brown1, C. Zenobi1, C. Moskowitz1, M. Hsu2, G. Getrajdman1, C. Sfoociealos2, J. Erinjeri1, A. Covey1, L. Brody1, H. Yarmohammadi1, D. Li1, A. Deipolyi1, Y. Bryce1, W. Alago1, R. Siegelbaum1, J. Durack1, R. Thornton1, A Gonzalez Aguirre1, E. Ziv1, F. Boas1, S. Solomon1, 1Memorial Sloan Kettering Cancer Center, New York, NY

**Purpose:** To compare the effect of autologous blood patch injection (ABPI) versus BioSentry hydrogel tract plug (BioSentry) on the rate of pneumothorax in image-guided percutaneous lung biopsy.

**Materials:** Our Institutional Review Board approved this randomized prospective clinical trial. A non-inferiority design for ABPI with a 10% margin was set with a target patient population of 552 (276 in each arm). From October 2014 all patients referred for image-guided percutaneous lung biopsy (N = 2052) were assessed for enrollment. A total of 1598 patients were excluded. In February 2017 the study was closed to accrual after an interim analysis. The study group consisted of 454 patients randomized into ABPI (n = 226) versus BioSentry (n = 228) arms. Analyses were performed on a modified intent-to-treat basis on 407 randomized patients who received lung biopsy using a z-test.

**Results:** Pneumothorax rates within 2 hours of biopsy were 21% (42/199) and 29% (60/208) for ABPI and BioSentry arms, respectively. Chest tube rates for ABPI and BioSentry arms were 9% (n = 18) and 13% (n = 27), respectively. Delayed pneumothorax rates within 2 weeks of biopsy were 2% (n = 3) and 1% (n = 3) for ABPI and BioSentry arms, respectively. The difference in the proportions of pneumothorax within 2 hours between ABPI versus BioSentry (-7.7%) along with the corresponding 95% confidence interval of the difference (-16.1%, 0.6%) and the tests of non-inferiority (p<.0001) exceeded the stopping boundary for noninferiority of ABPI arm and the study was closed to accrual prior to reaching the target total patient population of 552.

**Conclusions:** Autologous blood patch injection is not inferior to BioSentry regarding iatrogenic pneumothorax in image-guided percutaneous lung biopsy.

- Patient refused (396)
- Coaxial 19 G technique not used (27)

3:36 PM Abstract No. 95

**CT-guided 18-gauge core needle biopsy is safe for pulmonary nodules ≤1.0 cm and ≤0.8 cm with high diagnostic yield**

W. Foss1, E. Joiner1, Z. Cizman1, R. Hardman1; 1University of Utah, Salt Lake City, UT

**Purpose:** To evaluate the diagnostic yield and complication rate of CT-guided 18 G core biopsy of small lung nodules.

**Materials:** From January 2015 to July 2017, 491 patients underwent percutaneous CT-guided biopsy of pulmonary nodules using a 17 G trocar and 18 G core device. 90 patients had nodules ≤ 1 cm. 45 patients had nodules ≤ 0.8 cm. Core biopsies were taken with 18 G core biopsy instruments. Post biopsy CT was performed to identify pneumothorax, parenchymal hemorrhage, or hemothorax. Chest radiography was performed at 1 hour and 3 hours post biopsy. Clinically significant pneumothoraces were treated with chest tube placement and overnight admission. Nodules were measured in long and short axis on a PACS imaging system. Patient demographics, pertinent characteristics, complications, and pathology results were collected via chart review.

**Results:** Mean patient age was 60.2 years ± 15.9 for nodules ≤ 1 cm and 61.1 years ± 15.1 for nodules ≤ 0.8 cm. Mean lesion size was 0.81 cm ± 0.15 for ≤ 1 cm and 0.69 cm ± 0.10 for ≤ 0.8 cm. Diagnostic biopsies were obtained in 84/90 patients (93.3%, p-value 0.0037) for nodules ≤ 1 cm and 42/45 patients (93.3%, p-value 0.0252) for nodules ≤ 0.8 cm compared to the yield in this cohort of 397/401 (99.0%) for lesions > 1 cm. Any pneumothorax on chest radiography was noted in 26/90 (28.9%) and 15/45 (33.3%) patients in the ≤ 1 cm and ≤ 0.8 cm groups. Clinically significant pneumothoraces occurred in 6/90 (6.57%) and 2/45 (4.4%) patients in the ≤ 1 cm and ≤ 0.8 cm groups compared to 35/401 (8.7%) for > 1 cm lesions. Other complications in the ≤ 1 cm group were one bronchopleural fistula, 10 patients with hemoptysis (11.1%), and 6 patients with hemothorax (6.7%). The ≤ 0.8 cm group had 6 patients with hemoptysis (13.3%) and 3 patients with hemothorax (6.7%).

**Conclusions:** Fleischner society recommends biopsy as an option for management of pulmonary nodules over 1 cm, however, few studies exist evaluating the yield and safety of biopsy under 1 cm. This cohort demonstrates that core biopsy of small pulmonary masses provides high diagnostic yield of 93.3% compared to the literature rate of 77%, without significant difference in complications compared to biopsy of lesions over 1 cm.
3:45 PM Abstract No. 96

CT-fluoroscopy in subcentimeter lung nodule biopsy: does it make a difference?

Q. Han1, R. Jayavarapu2, M. Mufty1, A. Christie1, C. Qian1, S. Sanamprud1, D. Turner1, M. Winkler2, D. Raisi1; 1University of Kentucky, Lexington, KY; 2University of Kentucky, Lexington, KY

Purpose: Percutaneous lung nodule biopsy plays a critical role in the diagnosis, staging and therapeutic planning of primary and metastatic lung malignancies. However, sampling of subcentimeter lesions remains technically challenging and often leads to increased rate of diagnostic failure. We retrospectively reviewed our subcentimeter lung nodule biopsies using CT-fluoroscopy (CTF) to evaluate diagnostic accuracy, radiation dose and complication rate in the context of anatomical location, imaging features and technical intraprocedural data.

Materials: We determined the diagnostic accuracy of CTF-guided biopsy of nodules 9-10 mm and 6-8 mm in size, respectively, using core sampling or core sampling plus fine-needle aspiration (FNA). Location of the nodule, nodule imaging characteristics, presence of known malignancy, and associated complications were recorded. Independent risk factors for diagnostic accuracy, radiation dose and complications were determined with multivariate logistic regression analysis.

Results: After IRB approval, search on our PACS yielded 791 lung biopsies in the past 5 years, 58 of which were subcentimeter. With exclusion criteria, 46 cases are recruited for diagnostic accuracy analysis and 52 for radiation dose and associated complication. Overall the diagnostic accuracy is 84.8%. However, the cohort (14 cases) with both core and FNA samples has higher accuracy of 92.9%, vs. 81.3% with only core samples (32 cases), in par with reported literature. Logistic regression did not reveal any significant difference in biopsy accuracy or radiation doses against nodule characteristics, location or depth. However, the increased true positive yield with each 1 mm increase in size of nodule has an odds ratio (OR) up to 1.20 (95% CI: 0.73-2.00). The minor and major complication rate was 32.7% and 21.2%, per SIR criteria, respectively. Particularly, there is increased risk of major complication for upper lobe nodules, with OR of 2.9 (95% CI: 0.68-7.86) vs. other lobes.

Conclusions: CTF-guided percutaneous subcentimeter lung nodule biopsy in the range of 6-10 mm offers high diagnostic accuracy. However, there is relatively high risk for major complications, particularly for the upper lobar nodules.

4:03 PM Abstract No. 98

Initial large core needle biopsy (LCNB) of suspicious thyroid nodules: sequential cohort series without and with cytopathologist rapid onsite evaluation (ROSE)

R. Florok1, M. Helm2, J. Brown3, M. Crosier1; 1Lourdes Regional Medical Center, Lafayette, LA; 2West Jefferson Medical Center, Metairie, LA; 3West Jefferson Medical Center, Marrero, LA

Purpose: Thyroid nodule biopsy can have inadequate or indeterminate results and frequently requires re-biopsy. This study was done using a 14-gauge large core needle (LCNB) for initial biopsy of suspicious nodules to evaluate: 1) safety and efficacy; 2) reduction of non-diagnostic (ND) and uncertain (AUS/FLUS) results; and 3) use of rapid on-site evaluation (ROSE) by a cytopathologist.

Materials: A total of 308 thyroid biopsies of a solitary (180) or largest (128) nodule were done with ultrasound guidance using a
4:21 PM Abstract No. 100

Needle-based piezoelectric systems for guided biopsy tissue targeting
R. Oklu1, X. Yu2, M. Salomao1, H. Albadawi1, 1Mayo Clinic Arizona, Phoenix, AZ; 2Northwestern University, Evanston, IL

Purpose: US and CT are helpful in guiding needles to tumor tissue; however, accuracy and utility of these imaging tools can be limited when lesions are small. We introduce and test a class of ultrathin, needle-shaped piezoelectric microsystems mounted on biopsy needles to measure modulus. The aim was to test whether this strategy can improve the success rate of percutaneous biopsies.

Materials: The modulus-sensing probe was constructed with the piezoelectric material lead zirconate titanate (PZT) to provide mechanical actuation (distant from the tip) and sensing (near the tip). Modulus data was obtained by applying voltage to the mechanical actuator and measuring the induced voltage of the sensor. Extensive testing included finite element modeling, in vitro testing in PDMS and agarose, human and rat ex vivo tissues, testing in wide range of normal and neoplastic tissues including recipient livers. Furthermore, correlation of modulus data was made to magnetic resonance elastography results to validate the needle based technology. The study was IRB and IACUC approved. Statistical analysis was performed using Prism software (p<0.05).

Results: In vitro testing of the modulus sensor revealed that sensor signal increases linearly with actuator voltage moduli between 1 and 105 kPa-a linear range compatible with most tissues and organs. Subsequent testing in a wide range of rat in vivo and pathologic ex vivo tissues revealed consistent values with inter-variability resulting from intrinsic differences in the stiffness of tissues tested i.e., fat vs muscle. Further testing of fresh recipient livers showed that the needle sensor could distinguish reproducibly tumor tissue from adjacent cirrhotic tissue; the ratios correlated to MRE imaging data.

Conclusions: The results indicate a significant difference in modulus between normal and diseased tissue, easily detectable by the sensor and sufficient for use as a guiding signal to aid in needle positioning during biopsies.
Results: Eight patients (5 men, 3 women; mean age: 69.0 ± 11.2 years) underwent prophylactic arterial embolization for lower GI bleeding following inaprocedure CBCT during the study period. No procedure-related AEs occurred. Coils were used in 6/8 cases and n-butyl cyanoacrylate glue was used in the remaining 2 cases. 25% (2/8) patients had no repeat bleeding within 1 week. Of the patient who re-bled, 66.6% (4/6) patients had negative repeat CTA and/or colonoscopy. 33.3% (2/6) patients had a positive repeat CTA with arterial extravasation in the same region but no active bleeding on subsequent endoscopy; one patient rebled within two weeks with another positive repeat CTA but once again did not demonstrate active bleeding on endoscopy. One patient with negative repeat CTA proceeded to small bowel resection after ileocolic branch embolization for persistent bleeding. The remaining 4 patients had no documented repeat LGIB at 30 days.

Conclusions: Prophylactic arterial embolization for LGIB bleeding using CBCT may be safe in patients with active arterial extravasation noted on preprocedure CTA but not seen on mesenteric angiography. However, rates of rebleeding are high in these patients and thus close clinical monitoring is recommended.

SCIENTIFIC SESSIONS: MONDAY

3:00 PM Abstract No. 101

Utility of cone-beam computed tomography in lower gastrointestinal bleeding: safety and technical feasibility of prophylactic embolization

P. Shukla¹, M. Cristescu², M. Syed³, V. Bishay⁴, M. Ranade⁵, E. Kim⁶, F. Nowakowski⁷, R. Patel⁸, R. Lookstein⁹, A. Fischman³; ¹Mount Sinai Hospital, The Icahn School of Medicine, New York, NY; ²Mount Sinai Hospital, New York, NY; ³NYIT College of Osteopathic Medicine, Old Westbury, NY; ⁴Icahn School of Medicine at Mount Sinai Hospital, New York, NY; ⁵Mount Sinai Medical Center, New York, NY

Purpose: To evaluate the safety and efficacy of prophylactic arterial embolization for lower gastrointestinal bleeding (LGIB) utilizing cone beam ct (CBCT) in patients with a positive preprocedure CT angiogram (CTA) and no extravasation noted on mesenteric angiography.

Materials: Between September 2014 and August 2017, patients who underwent prophylactic arterial embolization for lower GI bleeding were retrospectively identified. All patients had active bleeding noted on preprocedure CTA and no evidence or arterial extravasation on intraprocedure mesenteric angiography. Subsequently, CBCT was performed and superimposed onto the preprocedure CTA to identify the offending vessel. Chart review provided demographic data, pertinent past medical history, procedural information, rebleeding, and procedure related adverse events (AEs) were recorded.

Results: A total of 134 patients (mean age, 59.7 years; range, 14-82 years) received TAE for LGIB identified on angiography. The bleeding focus was small bowel in 74 patients (55.2%), colon in 35 (26.1%), and rectum in 25 (18.7%). Technical success was achieved in 127 patients (94.8%). The clinical success rate was 63% (80/127); there were 31 recurrent bleedings, 13 TAE-related major complications that resulted in operation or mortality and 3 deaths due to underlying disease within 1 day after TAE. The rates of recurrent bleeding, major complication and in-hospital mortality were 25%, 18.5% and 24.2%. Embolized artery number, and the use of NBCA were significant prognostic factors associated with clinical outcomes.

Conclusions: Transcatheter arterial embolization for acute lower gastrointestinal hemorrhage: a 12-year experience of safety, efficacy and predictors of outcomes

J. Won¹, K. Joon Ho¹, K. Man Deuk¹, K. Han¹, W. Choi¹, Y. Kim¹, J. Lee¹, G. Kim¹, D. Lee¹, H. Kim¹; ¹Severance Hospital, Yonsei University College of Medicine, Seoul, Korea

Purpose: To investigate the safety and efficacy of transcatheter arterial embolization (TAE) in the management of lower gastrointestinal bleeding (LGIB) and to determine the prognostic factors associated with clinical outcomes.

Materials: Between December 2005 and April 2017, 919 patients were admitted to our hospital with symptoms of gastrointestinal bleeding, and the patients with positive angiographic findings for LGI were included in a retrospective study. Technical success and clinical outcomes including rates of clinical success, recurrent bleeding, major complication and in-hospital mortality for TAE were evaluated. The prognostic factors associated with clinical outcomes were analyzed.

Results: A total of 134 patients (mean age, 59.7 years; range, 14-82 years) received TAE for LGIB identified on angiography. The bleeding focus was small bowel in 74 patients (55.2%), colon in 35 (26.1%), and rectum in 25 (18.7%). Technical success was achieved in 127 patients (94.8%). The clinical success rate was 63% (80/127); there were 31 recurrent bleedings, 13 TAE-related major complications that resulted in operation or mortality and 3 deaths due to underlying disease within 1 day after TAE. The rates of recurrent bleeding, major complication and in-hospital mortality were 25%, 18.5% and 24.2%. Embolized artery number, the use of N-butyl cyanoacrylate (NBCA) and the origin of feeding artery were significant prognostic factors for recurrent bleeding. Underlying vascular disease, the embolized artery feeding artery were significant prognostic factors for major complications.

Conclusions: Transcatheter arterial embolization was a safe and effective treatment modality for LGIB patients, especially NBCA could be a primary choice as embolic material with a high rate of clinical success.
Balloon-assisted Onyx embolization of high-flow peripheral arteriovenous malformations with dual-lumen coaxial balloon microcatheter: technical aspects and clinical results

F. Kang1, K. Shah1, H. Park1, V. Gendel1, S. Roychowdhury1, J. Nosher1, C. Gribbin1; 1Rutgers-Robert Wood Johnson Medical School, New Brunswick, NJ

**Purpose:** The aim of this study was to demonstrate our experience in balloon-assisted Onyx (ethylene vinyl alcohol copolymer) embolization of high-flow peripheral arteriovenous malformations (AVMs) using dual-lumen coaxial balloon microcatheter technique, which does not necessitate a plug formation around the catheter that is required to allow antegrade flow of Onyx while preventing reflux and non-target embolization. This study expands the technique with its utilization on types of AVMs not described previously.

**Materials:** Three patients with peripheral high-flow AVMs treated with balloon-assisted Onyx embolization using dual-lumen coaxial balloon microcatheter were retrospectively analyzed. AVMs were located in the kidney, pelvis, and chest wall. One patient required two sessions of Onyx embolization treatment. A total of 4 sessions were performed with Onyx 18 and/or Onyx 34 using Scepter XC occlusion balloon catheter. Imaging and clinical follow-ups were performed for all patients.

**Results:** Technical success was achieved in all patients. Complete devascularization was obtained in two patients with renal and pelvic AVMs with one treatment, while the patient with chest wall AVM required two sessions, which resulted in complete devascularization. There was no evidence of excessive reflux of Onyx (AVM) or entrapment of the microcatheter. Non-target Onyx embolization or microcatheter fracture was not observed. After the final treatment, all patients were free of symptoms on clinical follow-up, and there was no evidence of recurrence identified on follow-up imaging.

**Conclusions:** From our single-institutional experience, the technique using dual-lumen coaxial balloon microcatheter for balloon-assisted Onyx embolization appears to be safe and effective in treating high-flow peripheral AVMs, while allowing more precise injection of Onyx with the capability to reduce the risks associated with reflux of Onyx.

Target vessel size for bariatric embolization: a comparative histologic evaluation of swine and human fundi

J. Vairavamurthy1, R. Anders2, D. Kraitchman3, A. Arepally4, C. Weiss5; 1University of Maryland School of Medicine, Baltimore, MD; 2Johns Hopkins University School of Medicine, Baltimore, MD; 3Johns Hopkins University, Baltimore, MD; 4Piedmont Healthcare, Atlanta, GA

**Purpose:** Bariatric Embolization is a new endovascular procedure, developed for obesity treatment. BEAT Obesity is an investigator-initiated IDE, designed to assess the safety and efficacy of BAE to treat morbidly obese patients using 300-500μm Embospheres. We present our 12-month safety and efficacy data.

**Materials:** Morbidly obese (BMI of 40-60) adult patients without comorbid conditions (n = 20, 4 male) were enrolled. Primary endpoints were weight loss and 30-day adverse events (AEs). Secondary endpoints (12-month follow-up) are: blood pressure, lipid profile, serum obesity hormones (Ghrelin, Leptin, GLP-1, PYY), hunger/satiety assessments, quality of life (QOL) (SF-36 and IWQOL) surveys, endoscopy and gastric emptying results. Complete 12-month data are presented.

**Results:** Mean age and BMI were 44.5 ± 10.7 years and 45.1 ± 4.1 kg/m², respectively. The left gastric artery alone (LGA) was embolized in 5 patients and the LGA and gastroepiploic arteries were embolized in 15 patients. No major AEs occurred. Small superficial ulcers were seen in 8 of the 20 patients at 2-week endoscopy, all of which had resolved at 3-month endoscopy. There was 1 case of transient sub-clinical pancreatitis. Six patients were discharged the evening of their procedure, and the remainder stayed for the indicated <48 hr hospital stay for control of nausea, vomiting and pain. There was 8.3 ± 3.9% (n = 20), 11.5 ± 5.5% (n = 18), 12.8 ± 7.7% (n = 14), and 11.7 ± 10.8% (n = 12) Excess Weight Loss at 1, 3, 6, and 12 months, respectively. There was a trend towards improvement in QOL parameters and decreased appetite scores. Full updated hormonal profiles for all patients will be presented.

**Conclusions:** Complete twelve-month data from the BEAT Obesity trial demonstrates that bariatric artery embolization is well-tolerated in severely obese patients. BAE appears to have sustained weight loss up to 12 months post procedure. Future clinical trials will focus on improving efficacy while maintaining the tolerated safety profile.
assessment of the corresponding vessels in human fundal sections from normal obese human patients.

**Materials:** Four healthy juvenile swine underwent bariatric arterial using 50-μm spherical embolics and the animals were humanely euthanized after four weeks for pathological analysis. The stomachs were harvested and representative fundal sections were collected and processed for routine H&E histology. Concurrently, gastric fundal remnants from patients who had undergone gastric bypass were obtained (n = 18) and representative sections were fixed in formalin and processed for routine H&E histology. In both cases, slides were scanned at 20X magnification using a NanoZoomer Digital Slide Scanner (Hamamatsu Corporation Japan). Vessels in the region where embolic deposition was identified in swine were measured and averaged using Halo software (Indica Labs, Corrales, New Mexico) and verified by a board-certified pathologist. Arteries in a similar histologic region in the submucosa were then measured in the human fundal sections, and also verified by a board-certified pathologist.

**Results:** Presence of 50-micron embolics was confirmed in the fundus in all experimental animals with specific deposition in arteries located in the luminal half of the submucosal layer. Average blood vessels in this region measured 49.3 ± 30.2 microns (n = 27) in the experimental swine. The average vessel size in this same region in the human fundal sections was 39.9 ± 29.9 microns (n = 337).

**Conclusions:** Based on this histopathologic analysis, a bead measuring closer to 50-80 microns could theoretically be used in future human bariatric embolization trials to mimic the weight loss and safety profile observed in the swine model.

### 3:45 PM Abstract No. 106

**Comparing solid embolic devices for the embolization of pulmonary arteriovenous malformations: an update**

C. Bailey, P. Choi, J. Betz, M. Duvvuri, M. Towsley, S. Mitchell, C. Weiss; 1Johns Hopkins Hospital, Baltimore, MD; 2N/A, Baltimore, MD; 3Johns Hopkins Bloomberg School of Public Health, Baltimore, MD; 4Johns Hopkins Hospital, Baltimore, MD; 5The Johns Hopkins University School of Medicine, Baltimore, MD

**Purpose:** Accepted practice is to treat all PAVMs greater than 2-3 mm using transcatheter embolization in order to prevent paradoxical emboli, aneurysm rupture, and chronic hypoxemia secondary to shunting. Though multiple solid embolic devices have been used to occlude PAVMs, coils remain the most commonly used despite recanalization rates as high as 15%. An alternative to coils is the Amplatzer Vascular Plug and the MicroVascular Plug System which allow for the occlusion of small feeding vessels with a single device. We compared these three embolic devices for the treatment of PAVMs specifically investigating procedural attributes, outcomes, and costs.

**Materials:** We performed an IRB approved retrospective review on all patients with PAVM treated exclusively with coils, AVP or MVP between October 2014 and July 2016. Procedural attributes, costs, and recanalization rates were collected and compared. Technical success was defined as complete occlusion of the feeding artery supplying the PAVM. Recanalization and revascularization were assessed by routine clinical follow-up and confirmed using CT angiography of the chest.

**Results:** A total of 68 patients with 102 PAVMs treated in 72 procedures were included. All procedures were technically successful without any minor or major complications. Multiple Regression was used to assess the association between clinical outcomes, adjusting for patient age, sex, HHT status, total AVMs treated per session, and mean feeding artery diameter. There was no significant difference between procedural time, fluoroscopy time, and contrast administered between our three groups. In terms of cost of embolic per procedure AVP was 69% cheaper than coils (95% CI 59-76% p <0.0001) and 50% cheaper MVP (95% CI 38-60% p <0.0001). MVP was 37% cheaper than coils (95% CI 14-54% p = 0.0038). Recanalization rates: Coils 15% with average follow-up of 597 days; AVP 7% with average follow-up of 481 days; MVP 0% with an average follow-up of 235 days.

**Conclusions:** Transcatheter embolization using solid embolics is safe and effective. Based on our analysis AVP is the most cost effective embolic with a lower rate of recanalization when compared to coils. MVP demonstrated the lowest recanalization rate.

### 3:54 PM Abstract No. 107

**Intermediate-term results of the microvascular plug (MVP) for treatment of pulmonary arteriovenous malformations**

M. Conrad, B. Ishaque, M. Dickey, R. Kerlan, M. Wilson, S. Hetts; 1University of California, San Francisco, San Francisco, CA; 2San Francisco General Hospital, San Francisco, CA; 3UCSF, San Francisco, CA

**Purpose:** To evaluate intermediate-term results for embolotherapy of pulmonary arteriovenous malformations (PAVMs) using the Micro Vascular Plug (MVP).

**Materials:** Patients with HHT and PAVMs treated by MVPs between October 2014 and January 2017 were retrospectively reviewed. Data collected included age, gender, number and type of PAVM, feeding artery size, device migration, aneurysmal sac size and perfusion. Technical success was defined as immediate intra-procedural angiographic occlusion of the feeding artery beyond the plug. Successful intermediate-term treatment was defined in 2 ways: 1. No sac enhancement (no perfusion of the PAVM sac on follow-up contrast-enhanced CT), and 2. No persistence (> 70% reduction in PAVM sac diameter on latest available CT). MVP-3, 5, 7 and 9 were chosen to embolize feeding arteries measuring <3, 3-5, 5-7, and 9 mm respectively.

**Results:** One hundred and twenty-two MVPs (91 MVP-3, 28 MVP-5, 2 MVP-7, and 1 MVP-9) were deployed in 106 PAVMs (82 simple, 24 complex). Average feeding artery size was 2.6 mm (1.1-7.4 mm). Immediate technical success was achieved in 115 of 122 (94%) deployments. CT was available for 19 patients (18 female, 11 male) with 67 treated PAVMs with an average age of 41. Average latest available CT follow-up: 14.6 months (range, 5.6-38.8). There was no enhancement of the PAVM sac on CECT in 63 of 67 (94%) PAVMs. No persistence was seen in 50 of 67 PAVM (75%). There were 2 complications: One migration occurred when a MVP-5 placed in a 5 mm feeding artery migrated to the draining vein on 3 mo follow-up CT requiring re-embolization. One patient developed a toe microemboli after delayed electrolytic detachment.

**Conclusions:** Our series of 106 PAVMs treated with 122 MVPs demonstrated a high rate of immediate angiographic occlusion, and successful treatment on immediate follow-up CT with an average follow-up of 14.6 months. The MVP should be oversized beyond manufacturer recommendations to prevent migration, particularly when the draining vein is large.
Analysis of the outcome and secondary intervention for patients with rebleed following mesenteric angiogram for acute lower gastrointestinal bleed
A. Al Khalifah1, S. Osei-Bonsu2, S. Lowe3, V. Etezadi4; 1University of Maryland Medical Center, Elkridge, MD; 2University of Maryland Medical Center, Baltimore, MD; 3N/A, Ellicott City, MD; 4Department of Radiology University of Maryland, Baltimore, MD

Purpose: To analyze the outcome and secondary intervention for patients with rebleed following mesenteric angiogram for acute lower GI bleed.

Materials: This retrospective study reviewed 82 patients who underwent mesenteric angiograms performed for acute lower GI bleed in our institution between 2011 and 2016. 26 patients had a rebleeding episode after mesenteric angiography.

Results: Total of 82 procedures were done for patients with acute lower GI bleed. 26 patients had a rebleeding episode after mesenteric angiography. Of the 26 patients, 15 had negative prior mesenteric angiograms while 9 were positive cases. The results are summarized in the table.

Conclusions: Rebleed after mesenteric angiograms in our study was 32% (26/82). The most common secondary intervention was surgery and endoscopy with diverticulosis and hemorrhoids being the most common underlying etiologies.

Proximal versus distal embolization technique for treatment of reperfused pulmonary arteriovenous malformations
L. Cusumano1, N. Koney2, G. Duckwiler1, E. Lee1, J. McWilliams1; 1David Geffen School of Medicine at UCLA, Los Angeles, CA; 2David Geffen School of Medicine at UCLA, New York, NY

Purpose: To compare the success of proximal versus distal embolization technique for treatment of previously embolized, recurrent pulmonary arteriovenous malformations (rPAVMs).

Materials: Between July 2007 and July 2017, 16 consecutive patients underwent embolization of 41 previously treated rPAVMs within a single academic medical center with imaging follow-up. At the time of treatment, the mechanism of reperfusion (through or around the existing embolic) was characterized. Repeat embolization was performed either by embolizing proximal to or around the existing embolic (proximal embolization technique) or by embolizing distal to the existing embolic (distal embolization technique). Follow-up imaging was reviewed to determine the presence or absence of persistent perfusion of the rPAVM, which was defined as contrast opacification of the sac and/or draining vein. Persistent perfusion rates of the embolization techniques were compared.

Results: Mean patient age was 55.4 years (range, 38 to 75 years) and 68.8% were female. 13 patients (81.2%) had definite hereditary hemorrhagic telangiectasia (HHT). Of the 41 previously embolized PAVMs, 28 had reperfused through the existing embolic, 4 had reperfused around the existing embolic, and 9 had reperfused by both mechanisms. Eight of the 41 rPAVMs were treated with distal embolization technique, and 33 were treated with proximal embolization technique. Overall persistent perfusion rate of the re-embolized rPAVMs was 53.7% at median follow-up time of 280 days. Persistent perfusion was significantly less likely with distal embolization technique (1/8, 12.5%) than with proximal embolization technique (21/33, 63.6%) (p = 0.016).

Conclusions: Recurrent PAVMs are difficult to treat, with high rates of persistent perfusion following repeat embolization. Embolization distal to the existing embolic is significantly more likely to produce durable occlusion than embolization proximal to or around the existing embolic.
with the angiogram performed during embolization 83.3% of the time. Embolic material used included coils only (56.9%), Gelfoam only (7.3%), particles only (6.4%), liquid embolic only (5.6%), or a combination of the above (23.9%). For all cases evaluated, the clinical success, ischemic complications, recurrent bleeding, and in-hospital mortality were 67%, 0%, 33%, and 33.7%, respectively.

Conclusions: Modern equipment and techniques for trans-catheter arterial embolization have maximized technical success rates and minimized ischemic complications, but clinical success rates remain similar to historical controls.

Scientific Session 12
Pediatric Intervention

Monday, March 19, 2018
3:00 PM–4:30 PM
Room: 402B

3:00 PM Abstract No. 111

Pediatric lung biopsy: risk worth the reward? A single-center experience
R. Yoo1, Z. Jeng2, G. Gardner1, A. Chau1, J. Hernandez3, S. Desai1, H. Cleveland1; 1Texas Children’s Hospital, Houston, TX; 2Baylor College of Medicine, Houston, TX; 3Texas Childrens Hospital, Houston, TX

Purpose: To determine diagnostic yield and safety of image-guided lung biopsy in high-risk pediatric patients.

Materials: IRB-approved retrospective study of patients undergoing image-guided lung biopsy at a single pediatric institution from June 2000–April 2017. Total of 104 image-guided biopsies were performed for: infection (n = 66), malignancy (n = 8), or infection vs. malignancy (n = 30). Of the 104 patients, 90 patients (87%) were immunocompromised- post bone marrow transplant (n = 66), immunodeficiency (n = 20), organ transplant (n = 8), previously healthy (n = 7) and other (n = 7). Procedural complications graded using SIR classification.

Results: Overall, the diagnostic yield was 64/104 (62%). Of cases for infection, diagnosis was rendered in 35/66 (53%). Of cases to rule out malignancy, diagnosis was rendered in 7/8 (87.5%). Of cases to identify either cause, yield was 22/30 (73%), of which the diagnosis was: malignancy (n = 8, 37%), infection (n = 7, 32%), auto-immune (n = 3, 14%), benign (n = 4, 18%). Overall, 29 complications noted (28%). 20 minor (SIR A and B) complications (19%), 9 major complications noted (9%), including 4 patients with moderate pneumothorax requiring chest tube placement, 3 with moderate hemoptysis requiring extended intubation/ICU level of care, and 2 deaths. Of note, 11 minor (17%) and 7 major (11%) complications occurred in the subset of 66 patients receiving biopsy to isolate infection to tailor medical therapy.

Conclusions: Diagnostic yield of biopsy for infectious etiology was low at 53%, while complication rates were high with biopsies done for this indication resulting in an 11% major complication rate, including 2 deaths. Conversely, diagnostic yield of biopsy to exclude malignancy was high at 87.5% with low complication rates with biopsies done for this indication accounting for only 2 minor complications and no major complications. While image-guided lung biopsy can sometimes be helpful to isolate an organism to tailor therapy, its use warrants careful consideration in this high risk pediatric population subset due to lower diagnostic yield and higher complication rate.

3:09 PM Abstract No. 112

C-arm cone-beam computed tomography navigational overlay pediatric lung nodule biopsy: safety and technical success
G. Shivaram1, E. Monroe1, K. Koo1, A. Gill2, C. Hawkins2; 1Seattle Children’s Hospital, Seattle, WA; 2Emory University School of Medicine, Atlanta, GA

Purpose: To describe our initial experience with percutaneous lung nodule biopsy (PLNB) in pediatric patients using C-arm cone-beam CT (CBCT) with navigational overlay.

Materials: Thirty consecutive patients with pulmonary nodules of 48 mm or smaller underwent PLNB using CBCT with navigational overlay (XperGuide, Philips, Eindhoven, The Netherlands). Patient demographics, pre- and post-biopsy diagnoses, number of biopsy passes, complications, radiation, and technical success were evaluated.

Results: PLNB was performed for 32 nodules in 30 patients (19 male, 11 female, median age 186 months, range 26-273 months). Median patient weight was 55 kg (range, 8-97 kg). Prebiopsy diagnoses included metastatic sarcoma or other solid tumor (n = 10), leukemia/lymphoma (n = 9), infection (n = 9), CGD (n = 1) and PTLD (n = 1). Mean number of passes was 5 (range, 2-15). Diagnostic specimens were obtained in 26 of 30 patients (87%). 10 complications were encountered (33%). Including 7 pneumothoraces (4 requiring chest tubes), 1 hemothorax requiring chest tube, and self-limited pulmonary hemorrhages (n = 2). Mean and median radiation doses were as follows: fluoroscopy time 3 and 2.3 min, DAP (recorded in 25 patients) 22418 and 13149 Gy-cm², and AK 85 and 52 mGy.

Conclusions: Percutaneous lung nodule needle biopsy in pediatric patients can be performed accurately using CBCT with navigational overlay.

3:18 PM Abstract No. 113

Retrograde balloon gastrostomy tube placement in children less than 15 kilograms
Y. Chang1, A. Cantos2, H. Goetzman1, J. Reis3; 1University of Rochester Medical Center, Rochester, NY; 2University of Rochester/Strong Memorial Hospital, Rochester, NY; 3University of Rochester Strong Memorial Hospital, Rochester, NY

Purpose: Pediatric gastrostomy tube placement using antegrade, retrograde pigtail and combined antegrade-retrograde techniques
A retrospective review was performed of gastrostomy tube placements in children <15 kg between 2015 and 2017. Tubes were placed in a retrograde fashion using two pediatric Cope anchor sutures (Cook, Inc, Bloomington, Indiana), a micropuncture access set (Cook, Inc, Bloomington, Indiana), a high-pressure angioplasty balloon, and a standard profile 12 French balloon retention gastrostomy tube. Wire access was maintained through the stomach into the distal esophagus during the procedure. Immediate technical success rates and 30-day complications were reported as major or minor based on the SIR classification. Thirty-day catheter displacement rates were also reported.

Results: A total of 38 retrograde placements were performed. The mean patient age was 15.4 months and the mean weight was 7.67 kg. The technical success rate was 100%. Minor complications included 4 cases of mild insertion site irritation and 7 children with granulation tissue requiring silver nitrate application. Major complications included one case of peritonitis requiring a 5 day ICU admission and intravenous antibiotics followed by full recovery. One death occurred in a 4.4 kg child <24 hours post placement, later found to have sepsis from a catheter associated bloodstream infection. There were 8 catheter displacements within 30 days of the procedure due to balloon malfunction or inadvertent pulling of the tube. All displaced tubes were successfully replaced.

Conclusions: Retrograde placement of pediatric balloon retention gastrostomy tubes is technically feasible with an acceptable short-term complication rate; however, there is a significant 30-day catheter displacement rate.

Nationwide trends in pediatric percutaneous kidney and liver biopsies: is there a value proposition for interventional radiologists who can safely perform these procedures as outpatients?

3:27 PM Abstract No. 114

G. Gadodia1, A. Gill2, H. Hua3, R. Palmer4, C. Hawkins5; 1Cleveland Clinic, Cleveland, OH; 2Emory University Hospital, Norcross, GA; 3Children’s Healthcare of Atlanta, Atlanta, GA; 4Children’s Healthcare of Atlanta, Atalnta, GA; 5Emory University School of Medicine, Decatur, GA

Purpose: To investigate trends, costs, relative safety, and potential savings of inpatient versus outpatient percutaneous kidney and liver biopsies in the pediatric population.

Materials: Data on admission type and cost (using billed charges as a cost-surrogate) from all percutaneous kidney and liver biopsies performed from 2008-2015 was collected using the Pediatric Health Information System (PHIS), a comparative database of patient encounters from 44 US Children’s Hospitals. Regression analysis was performed to evaluate the annual trend in the biopsy patients admitted as inpatients vs outpatients. Costs were compared using the Tukey-Kramer Method (significance: p < 0.05). To assess safety of outpatient biopsies performed by interventional radiology (IR), data was collected on all percutaneous kidney and liver biopsies performed at a single, large tertiary care children’s hospital (“Hospital A”) from 2014-2017, using complications requiring escalation in care (SIR Classifications B-F) as a surrogate for safety.

Results: 7,835 kidney and 9,984 liver biopsies were performed by all specialties at all PHIS hospitals. Regression analysis showed a significant annual decline in percentage of kidney (-0.6%, p = 0.008) and liver (-3.0%, p = 0.01) biopsies. Notably, >15% and >10% of kidney and liver biopsies were still performed as inpatients as of 2015, respectively. Costs were significantly (p < 0.0001) higher for inpatient biopsies (mean: $65,872 + $201,572 for kidney, mean: $173,331+ $505,177 for liver) vs outpatients (mean: $13,410 + $7,385 kidney, mean: $10,338+ $7,273 liver). 223 kidney biopsies and 441 liver biopsies were performed on outpatients from 2014-17 by IR at Hospital A. Percutaneous kidney biopsy complication rate = 1.3% (1 SIR class C, 2 SIR class D). Percutaneous liver biopsy complication rate = 0.2% (1 SIR Class C).

Conclusions: A substantial percentage of pediatric patients are still admitted as inpatients for postprocedure monitoring following percutaneous kidney and liver biopsies. Our study shows that these procedures can be done safely by IRs as outpatients, offering substantial potential cost savings for healthcare systems.

3:36 PM Abstract No. 115

Portal vein recanalizations in pediatric liver transplant patients: single-center experience

H. Cleveland1, J. Hernandez2, D. Ashton1, A. Chau1, A. Nagaraj1, S. Pimplwal1; 1Texas Children’s Hospital, Houston, TX; 2Texas Children’s Hospital, Houston, TX; 3Baylor College of Medicine, Houston, TX

Purpose: Report clinical outcome of successful PV recanalization in pediatric liver transplant patients with chronic PVT.

Materials: Retrospective IRB approved pediatric cohort study of 12 liver transplant patients (average age at transplant 11 months, range, 8-21) with chronic main portal vein thrombosis (PVT) who underwent portal vein (PV) recanalizations between August 2012 and September 2017. Three patients with failed PV recanalizations were excluded. Nine patients (4 male, 5 female) who underwent 23 PV interventions with successful recanalization were further evaluated for complications. Average clinic follow-up was 441 days (range, 23-1120). Average duration of imaging follow-up was 287 days (range, 1-1093). Patient demographics, technical details and follow-up was recorded from time of transplant to most recent imaging and clinic visit. Complications were classified according to SIR standards.

Results: Transplant indication for all patients was biliary atresia. PVT with cavernous transformation was diagnosed by ultrasound or MRV. Average time to first PV intervention was 55 months (range, 19-149). Indications for intervention were: acute gastrointestinal bleeding (n = 13); newly elevated liver enzymes with known PVT (n = 3); new PV stenosis (n = 3); scheduled follow-up splenoportogram (n = 3); and hypersplenism (n = 1). Interventions included PV recanalization, angioplasty, and stenting; varix embolization; and portosystemic shunt embolization. Three PV stents were placed. A major complication was seen in one patient following trans-splenic access and post-tract embolization with Gelfoam. Active bleeding was noted at the access site which
required transfusion of blood products and ICU admission. No additional major complications were identified.

**Conclusions:** PV recanalizations in liver transplant patients with chronic PVT is low risk with excellent clinical outcome.

**3:45 PM Abstract No. 116**

An update of one institution’s experience with the use of arterial closure devices following femoral arterial puncture in children

J. Smith1, E. Monroe1, G. Shivaram2, D. Shaw2, K. Koo3; 1University of Washington, Seattle, WA; 2Seattle Children’s Hospital, Seattle, WA

**Purpose:** The use of arterial closure devices in achieving femoral hemostasis post procedure has been well documented in adults but insufficiently studied in the pediatric population. While manual compression followed by bed rest remains the standard following arterial access, this can pose specific challenges in children, oftentimes requiring increased nursing and monitoring. An earlier study of 38 patients concluded that the use of the Angio-Seal™ (Terumo Interventional Systems, Tokyo, Japan) device is safe in children with only a single complication. More recent experience with this device however, suggests a higher rate of complication. This retrospective review was completed to assess the safety and clinical outcomes associated with the use of the Angio-Seal™ arterial access closure device.

**Materials:** After approval from our Institutional Review Board, a retrospective analysis was completed including a review of our pediatric interventional radiology database and medical records to identify all children in whom an arterial closure device was deployed from June 2011- September 2017. Peri-procedural documentation was reviewed for preprocedure labs, clinical effectiveness in achieving hemostasis and complications related to the use of this device.

**Results:** During the study period, a total of 48 Angio-Seal™ devices were deployed in 40 consecutive patients. All operators were fellowship trained in adult interventional radiology and experienced in placement of Angio-Seal™ devices. All 48 device deployments were successful with immediate hemostasis and without the need for manual compression. Complications were present in 8/48 (16.7%) cases including 5 hematomas, 2 episodes of transient peripheral pulse loss requiring additional monitoring, 1 iliofemoral thrombosis requiring emergent thrombolysis, 1 occlusive dissection requiring thromboendarterectomy and patch angioplasty, and 1 pseudoaneurysm.

**Conclusions:** While the use of percutaneous arterial closure devices can be efficacious for achieving hemostasis, our experience demonstrates an unacceptably high rate of complications in children, contrary to prior reports. The deployment of such devices should be performed with prejudice in this population.

**4:03 PM Abstract No. 118**

Protein-losing enteropathy following thoracic duct ligation: diagnosis and treatment

D. Kwon1, G. Nadolski1, M. Itkin1; 1Hospital of the University of Pennsylvania, Philadelphia, PA

**Purpose:** Protein-losing enteropathy (PLE) is a condition characterized by severe loss of proteins in the intestinal tract. This report describes a series of pediatric patients who developed PLE following thoracic duct (TD) ligation.

**Materials:** A retrospective review of 3 consecutive patients (M/F = 2/1; mean age 5.5 years) who developed PLE following TD ligation was performed. Lymphatic imaging included Dynamic Contrast Enhanced MR lymphangiogram (DCRML) and/or intranodal lymphangiogram (IL).

**Results:** Two patients (P1, P2) developed PLE following TD ligation for post-cardiac surgery chylothorax and the third patient (P3) following TD ligation for idiopathic chylothorax. The
post-ligation course was complicated by anasarca, severe hypoalbuminemia (mean 1.4 mg/dL), and electrolyte imbalances in all subjects. P1 and P3 had elevated stool alpha1-antitrypsin (A1A) (mean 324 mg/dL; reference ≤54 mg/dL). A1A for patient P2 was not documented. On DCRML, all patients had an occlusion of the TD and retrograde lymphatic flow through the intestinal lymphatic duct with leakage of the contrast into the lumen of the intestines. For P1 and P2, conservative treatment with oral steroids, sildenafil, octreotide, heparin, and diet modification was unsuccessful. In these patients, IL was performed followed by percutaneous access of the intestinal lymphatic ducts and embolization with n-BCA glue resulting in rapid normalization of albumin and electrolyte levels and symptomatic improvement. In P3, treatment with low fat diet and supplementation similarly resulted in drastic improvement. On follow-up (mean 2.6 months), P1 and P3 remained asymptomatic with normal laboratory values while P2 developed recurrent PLE with lymphatic leak into the intestines 8 months after embolization that is currently being managed medically.

Conclusions: Our study demonstrated the unusual development of the PLE in patients following TD ligation due to development of the retrograde lymphatic flow into the intestinal lymphatic ducts. Conservative treatment should be the initial approach. However, if this is unsuccessful, lymphatic embolization should be considered. Further long-term follow-up is needed to determine the durability of this treatment.

4:12 PM Abstract No. 119

Are transjugular intrahepatic portosystemic shunts (TIPSs) effective and durable in pediatric patients? F. Bertino1, C. Hawkins2, G. Shivaram3, A. Gill4, A. Reposar5, D. Sze6, M. Lungren7, K. Koo8, E. Monroe9; 1Emory University, Atlanta, GA; 2Emory University School of Medicine, Decatur, GA; 3Seattle Children’s Hospital, Seattle, WA; 4Emory University Hospital, Norcross, GA; 5Stanford Health System, Stanford, CA; 6Stanford University Medical Center, Stanford, CA; 7Stanford, Stanford, CA; 8N/A, Kentfield, CA; 9University of Washington, Seattle, WA

Purpose: To examine the efficacy of TIPSs in the pediatric and adolescent population.

Materials: IRB-approved retrospective review of patients undergoing TIPSs placement at three large tertiary children’s hospitals from 2001-2017. Demographics, stent type, technical success, mean gradient reduction (MGR), complications and patency at 1, 6, 12, and 24 mo. are reported. Patients missing stent type information were excluded from analysis of this single variable.

Results: All 60 patients in the study period (mean age = 12.8y, range 2-20; mean MELD/PED score = 12.4, range 6-33) had ePTFE covered (52/56) or uncovered (4/56) TIPS placed. Stent type was missing in 4 patients. Stent diameter ranged from 8-10 mm. Major indications were acute variceal bleed with and without portal vein thrombosis (34/60; 3/34, and 31/34), primary (6/60) and secondary (11/60) prevention of variceal bleed, portal vein thrombosis without variceal bleed (5/60), and refractory ascites (2/60). Technical success = 91.3% (55/56). MGR = 8.2 mm Hg (range, 0-29). Patency rates at 1, 6, 12, and 24 mo = 97.9% (47/48), 97.6% (41/42), 93.7% (30/32), and 92.0% (23/25). Decrease in patient follow-up was due to: transplant within 1y (4/60), loss to follow-up before 1 mo (1/60), and stent age less than follow-up interval. Primary patency at 1, 6, 12, and 24 mo = 93.8% (45/48), 88.1% (37/42), 87.5% (28/32), and 84.0% (21/25). 4 patients had TIPS stenosis requiring intervention within: 1 mo = 1/48; 6 mo = 2/42; 24 mo = 1/25. 1 patient had occlusion with successful recanalization within 1 mo (4/48). 3 patients had occlusion with failed recanalization within: 1 mo = 1/48 and 12 mo = 2/32. Complications = 7 major (e.g., sepsis, hemoperitoneum, and death) (12.1%); 11 minor (e.g., encephalopathy) (18.3%). Mortality = 0.0% (3/60), due to hepatic necrosis at postprocedure day (PPD) 10 (1/3), sepsis at PPD 8 (1/3), and uncontrolled hemorrhage at PPD 16 (1/3).

Conclusions: TIPSs in children has comparable technical success, patency, and complication rates as in adults based on available peer-reviewed literature.

4:21 PM Abstract No. 120

Interventional radiology in the management of biliary complications in pediatric liver transplants: a single-center experience

J. Frenkel1, S. Reis2, D. Mobley3, R. England4, J. Weintraub5, J. Susman6, V. Sheynzon7, S. Breji8, S. Tulin-Silver9, P. Schlossberg1, J. Weintraub5, J. Susman6, V. Sheynzon7, S. Breji8, S. Tulin-Silver9, P. Schlossberg1; 1Albert Einstein College of Medicine, Bronx, NY; 2Columbia University, New York, NY; 3N/A, Brooklyn, NY; 4Columbia University College of Physicians and Surgeons, New York, NY; 5Columbia University/New York Presbyterian, Scarsdale, NY; 6New York Presbyterian/Columbia, New York, NY; 7N/A, New York, NY; 8Columbia University Medical Center, Brooklyn, NY; 9Columbia University Medical Center, New York, NY

Purpose: To demonstrate the important role played by interventional radiology in the management of biliary complications following pediatric liver transplantation, helping patients avoid reoperation.

Materials: We studied two hundred thirteen liver transplants at a single pediatric hospital in a large metropolitan area between 2006 and 2016 in 199 patients with a median age of 3.1 years. Patients with biliary strictures were managed percutaneously by interventional radiology or surgically by the transplant team. The location of biliary stricture (intrahepatic ducts or at the anastomosis), duration of internal and external drainage, number of balloon dilations, balloon diameter, time interval between dilations and success of percutaneous treatment were recorded. Patients with bile leaks were also identified and duration and success of biliary drainage was recorded.

Results: Thirty-one patients (14.5%) developed a biliary obstruction or biliary stricture and eight (3.7%) developed a bile leak. Technical success was achieved in 26 of 28 strictures (92.8%). Clinical success was achieved in 15 of the 21 anastomotic strictures (71.4%) and all 6 patients with intrahepatic strictures (100%). Larger maximum balloon diameter was associated with treatment failure, 6.25 mm vs. 4.5 mm in the successfully treated group using an independent t-test (P = .009). Patients who required more than 3 dilations were associated with decreased likelihood of success. (P = .006). Of the 3 patients with bile leaks who required percutaneous transcatheter cholangiography by IR, the biliary system was successfully accessed in 2 patients for a technical success
rate of 66%. Clinical success was achieved in both patients for a 100% clinical success rate.

Conclusions: Our study demonstrates the important role of interventional radiology in the management of patients with biliary complications. For a high percentage of patients, percutaneous treatment of biliary complications helps patients avoid reoperation.

Scientific Session 13
Radioembolization: Technique

Monday, March 19, 2018
3:00 PM–4:30 PM
Room: 404A

3:00 PM Abstract No. 121

Patient radiation exposure in transradial vs. transfemoral yttrium-90 radioembolization: a propensity score–matched analysis of over 1000 procedures
J. Loewenstern3, C. Welch1, S. Lekperic2, V. Bishay3, M. Ranade4, R. Patel5, E. Kim6, F. Nowakowski6, R. Lookstein4, A. Fischman1, Icahn School of Medicine at Mount Sinai, New York, NY; 2Icahn School of Medicine at Mount Sinai, Staten Island, NY; 3Icahn School of Medicine at Mount Sinai Hospital, New York, NY; 4Mount Sinai Hospital, New York, NY; 5Mount Sinai Medical Center, New York, NY

Purpose: The study aims to establish whether differences exist in patient radiation exposure (PRE) of those treated with a transradial access (TRA) compared to transfemoral access (TFA) approach for transarterial Y90 radioembolization (TARE) procedures in a large, matched sample.

Materials: 1,005 consecutive TARE procedures in 810 patients from 2013 to 2017 were reviewed. A propensity score matching (PSM) analysis matched the TRA and TFA groups on the basis of patient age, sex, weight, height, Y90 delivery type (TheraSphere or SIR-Sphere), and number of prior procedures from the same and opposite approaches. Matched groups were then compared by PRE measures including fluoroscopy time (FT), dose-area product (DAP), and cumulative air kerma (AK). Effect size (r) for each PRE measure was calculated.

Results: Prior to PSM, TRA and TFA groups differed significantly in regards to mean age (64.9 vs. 66.4 years), weight (78.4 vs. 75.3 kg), and number of prior procedures from the same (5.5 vs. 9.3% zero prior, 66.2 vs. 58.5% one prior, 28.3 vs. 32.2% two or more prior) and opposite approach (76.3 vs. 80.4% zero prior, 12.1 vs. 14.3% one prior, 11.6 vs. 5.3% two or more prior, p’s < 0.05). After PSM, each group consisted of 384 procedures each (n = 768) and no longer differed by any preprocedure measure (all p’s greater than 0.7). TRA was associated with longer median FT (9.20 vs. 7.79 min, p = 0.003) and increased median AK (322.15 vs. 219.46 mGy, p = 0.005) compared to the TFA group, while there was no statistical difference in median DAP (112,376 vs. 123,434 mGy*cm², p = 0.11). Effect sizes were 0.108, 0.194, and 0.058 for FT, AK, and DAP, respectively.

Conclusions: Although statistical significant differences were found for each PRE measure, the practical effect sizes are considered small for FT and AK and less than small for DAP. Thus, any differences in PRE between the radial and femoral approaches for TARE are minor and unlikely to be noticeable in everyday clinical practice.

3:09 PM Abstract No. 122

Lobar or whole-liver Yttrium-90 radioembolization using resin microspheres without prophylactic embolization of the gastroduodenal artery
M. Abdelmaksoud1, O. Abuelsaheen2, K. Ibrahim2, M. Abdelrazek1, A. Abdelfattah1, A. Abdelaziz2, A. Darwish2, M. Hassanien3, A. Ismail4, A. Hosny4, A. Hazem5, A. Sami5, Y.A. Fattah5, D. Sze5, Theodore Bilharz Research Institute, Saudia German Hospital, Cairo, Giza, CA; 2Theodore Bilharz Research Institute, Giza, Egypt; 3Stanford University Medical Center, Stanford, CA; 4Faculty of Medicine, Cairo University, Cairo, Egypt; 5Saudia German Hospital, Cairo, Cairo, Egypt; 6Stanford University, Stanford, CA

Purpose: Prophylactic embolization of the gastroduodenal artery (GDA) prior to 90Y radioembolization (RE) to prevent non-target deposition in the gastrointestinal (GI) tract may result in problematic collateralization. The purpose of this study was to assess the safety of lobar or whole liver 90Y RE using resin microspheres without embolization of the GDA.

Materials: All patients who underwent lobar or whole liver 90Y RE using resin microspheres without prophylactic embolization of the GDA from August 2011 to August 2017 were retrospectively reviewed. Selective embolization of other distal hepatico-enteric vessels was performed as needed. Microspheres were administered from lobar and more distal arteries, except 1 patient who underwent treatment from the proper hepatic artery (PHA). 5% dextrose was used as flush, and microspheres were used up to 24 hours pre-calibration (day-before dose). The incidence of GI toxicities within 3 months of treatment was evaluated.

Results: 76 patients underwent 95 lobar or whole liver treatments without embolization of the GDA. 73 patients (96.1%) had hepatocellular carcinoma, 2 (2.6%) had metastatic colorectal cancer and 1 (1.3%) had cholangiocarcinoma. Prophylactic embolization of distal hepatico-enteric vessels was performed in 11 patients (14.5%), most commonly the right gastric artery. Of the 76 patients, 48 (63.1%) received lobar treatment, 17 (22.4%) received treatment to one lobe plus one or more contralateral segments, and 11 (14.5%) received whole liver treatment either in a single session (n = 6, 7.9%, 5 bilobar and 1 PHA), or staged sequentially (n = 5, 6.6%). All infusions were completed without angiographic stasis. Follow up was available for 75 patients (98.7%). Only 2 patients (2.6%) developed grade 1-2 abdominal pain and anorexia that was relieved by medication. None of the patients developed a clinically evident gastric or duodenal ulceration.
Conclusions: Lobar or whole liver RE using resin microspheres can be done safely without prophylactic embolization of the GDA using dextrose and day-before doses. Distal hepatico-enteric communications may still require identification and embolization.

3:18 PM Abstract No. 123

Is a “phase 1” planning angiogram prior to radioembolization necessary for arterial anatomic delineation?

R. Gondalia1, J. Ronald1, W. Pabon-Ramos1, P. Suhocki1, C. Kim1; 1Duke University Medical Center, Durham, NC

Purpose: For patients undergoing radioembolization a “phase 1” or planning angiogram is typically performed prior to yttrium-90 microsphere infusion, to assess the hepatopulmonary shunt fraction and arterial anatomy for planning purposes. Given reports that a high shunt fraction is very rare with certain tumor types, with coil embolization becoming increasingly rare as well, the necessity for a planning angiogram has been questioned. The purpose of this study was to assess the adequacy of hepatic arterial CTA for delineating pertinent arterial anatomy.

Materials: Review of 191 patients who underwent radioembolization revealed that 68 patients had a high-resolution hepatic CTA prior to the procedure. The CTA and planning conventional angiographic images (DSA) were independently reviewed and assessed for ability to visualize the right gastric artery (RGA), right inferior phrenic artery (RIPA), gastroepiploic artery (GDA), and major anatomic variants (accessory or replaced right or left hepatic arteries). The location of the origins of the RGA and RIPA were assessed on both CTA and DSA and systematically categorized.

Results: On both CTA and DSA, the anatomic relationships of the common, proper, right, and left hepatic arteries were confidently visualized in 100% of patients. The GDA was confidently identified in 97% of patients on both CTA and DSA. The RGA was confidently identified in 79% on CTA and 84% of cases on angiography. The location of the origin of the RGA was correctly identified in 91% of CTAs, using DSA as the reference standard. Variant arterial anatomy was identified in 38% of patients based on DSA, with 100% concordance on CTA. The right phrenic artery was confidently identified in 100% of CTAs and on 40% of DSA studies. Using angiography as the gold standard, the CTA-derived location was 100% concordant.

Conclusions: High resolution CTA is highly accurate for delineating pertinent hepatic arterial anatomy. These findings suggest that it may be reasonable to skip the planning angiogram in patients undergoing CTA found to have favorable arterial anatomy and with tumor types that are low risk for hepatopulmonary shunting to minimize delay in treatment and inconvenience for patients.

3:27 PM Abstract No. 124

MIRD-based activity calculation may improve outcomes over body surface area for resin microsphere radioembolization of metastatic colorectal carcinoma

M. AbdelRazek1, M. Khalaf1, M. Abdelmaksoud2, M. Lam2, D. Wang1, J. Louie1, D. Sze1; 1Stanford University School of Medicine, Stanford, CA; 2Theodor Bilharz Research Institute, Giza, Egypt; 3UMC Utrecht, Zeist, Netherlands

Purpose: To compare clinical outcomes of resin microsphere Y90 radioembolization (RE) using standard Body Surface Area (BSA) activity prescription versus Medical Internal Radiation Dose (MIRD) prescription for treatment of metastatic colorectal carcinoma (mCRC).

Materials: Patients with mCRC treated with resin microsphere RE between 2004-2015 were retrospectively reviewed. Standard BSA activity prescription was used from 2004-2012. Starting 2013, MIRD-based activity prescription was substituted, with treated region absorbed doses ranging from 40-65 Gy depending on performance status, liver function, volume of treatment, hypervascularity, and previous treatment history. Radiographic, biochemical, and clinical outcomes were compared.

Results: Of 109 patients (61 M/48 F), median age 60, underwent 118 treatment sessions (96 BSA/22 MIRD). 77 underwent whole liver treatment, either single session (72) or staged (5). In the MIRD group, 7 (36%) patients had activity prescribed >10% greater and 3 (15%) had activity >10% lower than what would have been prescribed by BSA. Disease control rate (DCR) by RECIST 1.1 showed a trend favoring MIRD over BSA (71% vs 53%, p=0.1). MIRD patients showed more mild laboratory toxicity changes at 90 days (CTCAE 4.03, ≤ 2 grade change from baseline) (28% vs 18%, p=NS), but slightly less moderate and severe toxicity changes than BSA patients (>2 grade change from baseline) (0% vs 3%, p=NS). Median changes in serum carcinoembryonic antigen (CEA) in MIRD and BSA groups at 8 weeks after RE were -16% and -8% (p=NS). Differences in median hepatic progression-free survival did not reach statistical significance (MIRD 150 days vs BSA 90 days, p=0.5). Likewise, the study was underpowered to show a difference in overall survival (210 vs 321 days, p=0.4).

Conclusions: Using MIRD rather than BSA for activity calculation for resin microsphere Y90 RE of mCRC resulted in increase in dose in 36% and decrease in 15% of patients. Although additional statistical power is needed, consideration of the target liver volume rather than body surface area is a promising approach to increase the efficacy and decrease the toxicity of resin microsphere RE.

3:36 PM Abstract No. 125

Single-day outpatient yttrium-90 radioembolization using resin microspheres

M. Abdelmaksoud1, O. Abuelsaheen2, K. Ibrahim3, M. AbdelRazek4, A. Abdelfattah5, A. Abdelaziz6, A. Darwish7, M. Hassanien8, A. Ismail3, A. Hosny5, A. Hazem3, A. Sami5, Y.A. Fattah6, D. Sze7; 1Theodor Bilharz Research Institute, Cairo, Giza, Egypt; 2Theodor Bilharz Research Institute, Cairo, Giza, Egypt; 3Faculty of Medicine, Cairo University, Cairo, Egypt; 4Stanford University Medical Center, Stanford, CA; 5Theodor Bilharz Research Institute, Cairo, Giza, Egypt; 6Saudi German Hospital, Cairo, Egypt; 7Stanford University, Stanford, CA
Purpose: Preparatory angiography and $^{99m}$Tc-macroaggregated albumin (TcMAA) scintigraphy are usually performed on a separate day preceding the treatment day on candidates for $^{90}$Y radioembolization (RE) of the liver. This study assessed the feasibility of performing all procedures in one outpatient visit.

Materials: From 2011 to 2017, 29 patients with unresectable hepatic malignancy were treated by single day $^{90}$Y RE. Treatment was carefully planned based on pretreatment imaging, laboratory data, and volumetry. On the day of procedures, patients underwent hepatic angiography and TcMAA scintigraphy, followed by $^{90}$Y RE treatment using resin microspheres within two hours, and were discharged the same day.

Results: 29 patients underwent 33 procedures, and were successfully treated in single day outpatient visits. 27 patients (93.2%) had hepatocellular carcinoma (HCC), one (3.4%) had metastatic colorectal carcinoma, and one (3.4%) had metastatic pancreatic carcinoma. Of the HCC patients, tumor thrombus involved the main portal vein in 10 (30.3%), lobar vein in 5 (15.2%), and segmental vein in 8 (24.2%). At mapping angiography, 2 patients had high flow arterioportal shunts and 1 had an arteriovenous shunt which required preemptive particle embolization before TcMAA scintigraphy. Coil embolization was performed on 3 patients (9.1%) to prevent non-target deposition, and on 1 (3%) to consolidate arterial supply. Median lung shunt was 4% (1.3-18%) despite the high incidence of vascular invasion. Five (15.1%) patients received treatment to one or more segments, 19 (57.6%) to one lobe, 3 (9.1%) to the extended right lobe, and 6 (18.2%) to whole liver in a single session (3, 9.1%) or staged sequentially (3, 9.1%). Median activity delivered was 1.67 GBq (0.74 - 3.15 GBq). No grade 3 or 4 toxicities were documented.

Conclusions: Performance of single day outpatient $^{90}$Y radioembolization using resin microspheres is feasible despite treatment of high-risk patients. Extensive planning and coordination must be arranged, and bland embolization may be necessary to reduce shunting. Single day treatment can optimize utilization of resources and improve the patient experience.

Evaluation of a same-day radioembolization mapping and treatment protocol utilizing resin yttrium-90 microspheres for feasibility, safety, and efficacy

K. Chu1, R. Liu1, O. Zurkiya1, A. DePietro1, R. Arellano1, Z. Irani1, S. Ganguli1; 1Massachusetts General Hospital/ Harvard Medical School, Boston, MA

Purpose: Pretreatment mapping angiography with lung-shunt calculation is routinely performed at least 1-2 weeks prior to Y-90 microspheres administration for primary or secondary liver tumors. Same-day mapping and treatment has been performed using Y-90 glass microspheres. We evaluate the feasibility, safety, and efficacy of a same-day mapping and treatment protocol utilizing resin microspheres in a single, outpatient encounter.

Materials: All same-day radioembolization procedures after protocol implementation in February 2017 were included in this IRB-approved, HIPAA-compliant, single-institution retrospective study. Y-90 treatment dose was calculated using the modified BSA method. Tumor response was assessed using mRECIST criteria. Clinical side effects or adverse events were evaluated using CTCAE v4.0.

Results: Twenty-two same-day mapping and treatment procedures were included (8 men, 14 women; average age 62 years). Tumor types included neuroendocrine (11), breast cancer (4), hepatocellular carcinoma (3), sarcoma (2), melanoma (1), colorectal cancer (1). Twelve cases (55%) were right lobar, eight (36%) were left lobar, and two (9%) were whole liver treatments. Median lung shunt fraction was 3.1%. Of the 18 patients with follow-up cross-sectional imaging at one month, seven patients (39%) had complete response, five (28%) had partial response, four (22%) had stable disease, and two (11%) had progressive disease. At one-month follow-up, there was one grade 3 toxicity (nausea) and four (18%) grade 2 toxicities. The most common adverse effects were fatigue (41%), nausea (18%) and pain (14%).

Conclusions: A protocol combining pretreatment angiography mapping, $^{99m}$Tc-MAA scintigraphy, and Y-90 radioembolization with resin microspheres into a single-day, outpatient encounter is feasible, safe, and effective. This new paradigm expedites cancer therapy and offers increased convenience for patients.
TLDs used in this study, SIR-spheres hand doses averaged 12 mrem and 124 mrem per procedure for physician administration and technologist preparation, respectively. Body doses for technologists handling SIR-Spheres averaged 0.16 mrem ± 0.05 and 0.02 ± 0.04 mrem for Theraspheres. Body doses for physicians measured 0.1 mrem ± 0.1 mrem for SIR-spheres and were too low to measure for Therasphere.

Conclusions: Therasphere and SIR-Spheres therapies have generally low radiation exposure to hospital personnel when used in routine clinical cases. More data is needed to provide greater statistical significance of these preliminary results.

4:03 PM Abstract No. 128

Real-time feedback on Y-90 microsphere delivery efficiency
M. Vanderhoek; 1Henry Ford Hospital, Detroit, MI

Purpose: In Y-90 microsphere therapy, the prescribed tissue dose is achieved by effectively transferring all of the microspheres from the treatment delivery device (TDD) into the target tissue. Microsphere delivery efficiency is determined AFTER treatment via measurement of the residual microspheres in the TDD. A real-time dosimetry system was investigated in order to provide intra-procedural feedback on the presence of residual microspheres DURING treatment.

Materials: For 22 clinical Y-90 glass microsphere administrations (BTG Biocompatibles Ltd, Farnham, UK), a wireless RaySafe i2 dosimeter (Unfor’s RaySafe AB, Billdal, Sweden) was placed inside the TDD beneath the outlet tubing. During administration, the dosimetry system displayed the instantaneous radiation dose rate associated with microspheres transiting or remaining residual in the tubing. Dosimetric data was compared with standardized quantification of residual microspheres (%) post-therapy, in order to establish the dosimeter’s utility in predicting residual.

Results: During the 1 year study period, there were 22 administrations. Only 2 cases exhibited elevated residual, which is consistent with our institutional experience of elevated residual in ~10% of cases. In the 20 cases with minimal post-therapy residual (mean residual: 0.3% ± 0.1%), the instantaneous dose rate peaked and then rapidly decreased below 2% of peak within 9.5 ± 0.6 seconds. In the 2 administrations with elevated post-therapy residuals (5% and 2%), the real-time dose rate peaked but then slowly decreased and remained at approximately 20% of the peak thereafter, indicative of residual microspheres in the TDD. The persistent, elevated, real-time dose rate resulted in treatment delivery modification in 1 of these 2 cases. With treatment delivery modification, the post-therapy residual was 2%. Without delivery modification, the post-therapy residual was 5%.

Conclusions: The RaySafe i2 dosimetry system can reliably provide valuable, real-time feedback regarding residual Y-90 microspheres in the outlet tubing during patient treatment. Administering physicians can then make intraprocedural modifications to improve microsphere delivery efficiency for more complete treatment delivery.

4:12 PM Abstract No. 129

Intrahepatic flow redistribution prior to segmental Yttrium-90 radioembolization for challenging tumor vasculature
M. Kolber, P. Shukla, V. Bishay, M. Ranade, F. Nowakowski, R. Patel, R. Lookstein, A. Fischman, E. Kim; 1Mount Sinai Hospital, The Icahn School of Medicine, New York, NY

Purpose: Hepatic tumors with complex vascular supply, inaccessible feeding vessels, and/or poor tumor perfusion are prone to transarterial treatment failure. This concern is compounded in the setting of Yttrium-90 (Y90) radioembolization (RE), which is often non-embolic, flow-dependent, and relies on high threshold radiation dose for response. We describe our experience with intrahepatic flow redistribution using bland or coil embolization prior to RE of tumors with challenging vascular supply.

Materials: Between 4/2014-7/2017, 19 patients (14 male, median age 62) with focal hepatocellular carcinoma underwent embolization for the purpose of intrahepatic flow redistribution during RE mapping or treatment. Hepatic redistribution (HR) was performed by embolization of vessels supplying normal hepatic parenchyma in cases when flow was not preferential to target tumor. Tumor-specific redistribution (TR) was performed by embolization of accessory feeding vessels supplying the lesion, but not amenable to subselective RE. Lesion characteristics, vascular supply, treatment approach, angiography, and adverse events (AEs) were reviewed. Dosimetry coverage based on mTc-MAA and Y90 SPECT-CT was evaluated against pretreatment CT or MRI. Radiographic response was assessed by mRECIST.

Results: 13 cases of HR and 6 cases of TR were identified. Embolization was performed at the segmental (n = 4) or sub-segmental level (n = 14), and at the gastroduodenal artery (n = 1). Fourteen right and 5 left-sided HCCs were treated (mean size 3.7 ± 2.1 cm). Embolic material included: calibrated microspheres (n = 12, range 40-500 μm), detachable microcoils (n = 7), and Gelfoam (n = 1). There were no procedure-related AEs. Post-treatment SPECT-CT dosimetry coverage was concordant with target lesions in all cases. Mean follow-up was 7.2 ± 6.7 months. Tumor-specific response was 68% complete response, 11% partial response, 5% stable disease, and 16% progressive disease by mRECIST. No major adverse events or grade 3/4 hepatotoxicity occurred up to 30 days.

Conclusions: Intrahepatic flow redistribution prior to RE is safe with 79% objective response in the setting of complex vascular supply or poor relative tumor perfusion.

4:21 PM Abstract No. 130

An automatic nonrigid co-registration algorithm for fusion of cone-beam computed tomography and magnetic resonance imaging: feasibility in Y90 radioembolization for hepatocellular carcinoma
B. Marinelli, V. Bishay, M. Ranade, F. Nowakowski, A. Fischman, R. Lookstein, E. Kim, R. Patel; 1Icahn School of Medicine at Mount Sinai, New York, NY; 2Icahn School of Medicine at Mount Sinai Hospital,
Purpose: Cone-beam CT (CBCT) during Y90 radioembolization (RE) of HCC allows precise selection of tumor-feeding arteries and improves accuracy of dose delivery. Co-registration with prior MRI provides additional guidance, particularly in poorly enhancing lesions. Clinically available rigid co-registration algorithms cannot account for anatomy deformations from respiratory motion and require manual interaction. Acceptable co-registration quality is unpredictable and user-dependent, limiting adoption of CBCT-MRI fusion into clinical practice.

Materials: An automatic, non-rigid co-registration algorithm using the open source software packages ANTs, SLICER and Python was developed for fusion of preprocedural T1 late arterial phase MRI and CBCT acquired during the mapping phase of RE. Co-registration was performed in seven treatment-naive patients with ≤2 lesions measuring 2-10 cm. Clinically meaningful tumor and total liver volume overlays were assessed by two IR attending physicians on a nominal scale (0-5) and analyzed by the Wilcoxon test. Quantitative assessment of liver volume overlay by the non-rigid approach was performed using the dice similarity measure.

Results: Average scores for clinically meaningful overlay of target tumor(s) (4.3 vs. 4.3, p > 0.99) and liver volumes (4.5 vs. 4.5, p > 0.99) were identical for rigid and non-rigid algorithms. Dice similarity measure of liver volumes following non-rigid CBCT-MRI fusion was 0.88 ± 0.04. This is comparable to the best-reported measures in the literature for multi-modal, non-rigid liver co-registration.

Conclusions: Clinically relevant CBCT-MRI fusion in HCC using an automatic, non-rigid co-registration algorithm from open source software is feasible. With further development, adoption of this approach may improve reliability and accuracy of image guidance for RE.

---

**Scientific Session 14**

**Chemoembolization Techniques**

Monday, March 19, 2018
3:00 PM–4:30 PM
Room: 404B

**Abstract No. 131**

Comparison of response rates and explant analysis between endhole (EH) vs anti-re catheters in patients undergoing DEB-TACE for solitary LR-5 HCC tumors

J. Titanò, A. Fischman, R. Shrestha, H. Pollinger, L. Jacobs, S. Citron, M. Tully, A. Arepally, L. Stein, R. Rubin; Icahn School of Medicine at Mount Sinai, New York, NY; 2Mount Sinai Hospital, New York, NY; 3N/A, Atlanta, GA; 4Piedmont Healthcare, Atlanta, GA

**Abstract No. 132**

Complete stasis embolization may convey survival benefit in hepatocellular carcinoma patients treated with doxorubicin eluting bead transcatheter arterial chemoembolization

D. Moon, S. Fujimoto, U. Oyoyo; Loma Linda University, Loma Linda, CA

**Purpose:** To compare tumor response, liver toxicity, and tumor necrosis in HCC patients treated with DEB-TACE using two different catheter delivery systems: standard endhole catheter (EH) versus expandable-tip microcatheter (SIS).
in patients with hepatocellular carcinoma (HCC). In 2011, Jin et al demonstrated higher survival rate with substasis endpoints compared to higher stasis endpoints using conventional TACE (cTACE). The purpose of our study is to investigate whether substasis endpoints in the relatively new doxorubicin eluting bead (DEB) TACE has better survival when compared with complete stasis endpoints in HCC patients.

**Materials:** Retrospective cohort study was performed in HCC patients who underwent DEB TACE as their first line therapy from 2008-2016. Exclusion criteria included lack of post-embolization angiogram. The patients were classified based on the subjective angiographic chemoembolization endpoints (SACE) levels on the postembolization angiogram. The median survival rate was the primary outcome. Mean age of SACE groups 2, 3, and 4 were 62.7, 62.6, and 62.2 respectively. The M:F gender ratio for SACE groups 2, 3, and 4 were 2:1:1, 1:2, and 1:2.1 respectively. Kaplan-Meier curves were calculated to compare the survival rate between the different SACE levels, using significance level of 0.05.

**Results:** 155 patients were included in our study: 98 classified as SACE level 2, 30 as SACE 3, and 27 as SACE 4. Results show SACE 4 (median: 14.7 months) has better survival in patients who survived <25 months compared to SACE 2 (median: 9.4 mo.) or 3 (median: 10.1 mo.), p = 0.044. There may be higher median survival rate in patients who survived >25 months with SACE 2 (median: 31.2 mo. [IQR 10.9]) when compared with SACE 3 and 4 (median: 30.1 mo., [IQR 2.7] and 29.9 mo., [IQR 14.1] respectively), p = 0.65. Stratified analysis among these patients shows that the survival rate of SACE 2 and 3 (median: 30.2 mo., [IQR 10.2]) is similar to SACE 4 (median:29.9 mo. [IQR 14.1]), p = 0.46.

**Conclusions:** DEB TACE with SACE level 4 has better survival rate compared to SACE 2 or 3 by over 5 months, in HCC patients who survived less than 25 months. After 25 months, survival rates were similar. Complete stasis embolization may convey short-term survival benefit.

**3:27 PM**

**Abstract No. 134**

**Is smaller better for hepatocellular carcinoma? Evaluation of DEB-TACE bead size and cTACE in 142 explanted tumors**


**Purpose:** Chemoembolization (TACE) remains a mainstay in the treatment of hepatocellular carcinoma (HCC). Drug-eluting beads and smaller bead sizes have been introduced to improve locoregional treatment response. This study assesses imaging response characteristics and necrosis rates in patients with HCC who were bridged to transplant with TACE.

**Materials:** Retrospective analysis was performed on all patients who were treated for HCC with conventional TACE (cTACE) or TACE with drug-eluting beads (DEB-TACE) from 2/9/2005 to 2/6/2017 and subsequently transplanted (n = 142). Treatment response was based on modified RECIST imaging criteria. Posttreatment imaging response and necrosis rates at explant were compared with TACE type and drug-eluting bead size. 47 patients were treated with cTACE and 95 patients were treated with DEB-TACE. Of the 95 patients treated with DEB-TACE, 40 patients were treated with 100-300μ beads, 47 patients were treated with 70-150μ beads, and 8 patients were treated with 30-60μ beads.

**Results:** Initial and sustained treatment responses were similar in all groups (p = 0.38 and 0.33, respectively). Additionally, lesion count (p = 0.67), lesion size (p = 0.06), and pretreatment AFP (p = 0.60) were similar in all groups. The number of treatment cycles prior to transplant were also similar in all DEB-TACE groups (p = 0.36). However, fewer treatment cycles were noted in the cTACE group (p = 0.05). At explant, higher necrosis rates were noted in the cTACE group compared to all DEB-TACE groups.
Efficacy and safety of drug-eluting beads transarterial chemoembolization by CalliSpheres® in 275 hepatocellular carcinoma patients: a result from CTILC study

G. Cao1, G. Zhou2, T. Hu3, J. Sun2; 1Shulan (Hangzhou) Hospital (Zhejiang University International Hospital), Hangzhou, Zhejiang Province; 2The First Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang Province; 3Zhejiang Provincial People’s Hospital, Hangzhou, Zhejiang Province

Purpose: To investigate the efficacy and safety of drug-eluting beads transarterial chemoembolization (DEB-TACE) treatment in Chinese HCC patients and the prognostic factors for treatment response as well as survival.

Materials: 275 HCC patients about to receive DEB-TACE treatment were prospectively included in this study. Treatment response was assessed by mRECIST criteria, and OS was calculated. Liver function indexes and AEs were evaluated before and after DEB-TACE operation.

Results: CR, PR and ORR were 22.9%, 60.7% and 83.6%, respectively. Mean OS was 380 (95% CI: 370-389) days, and the 6-months OS rate was 94.4% ± 1.7%. Multivariate logistic regression revealed that portal vein invasion (P = 0.011) could independently predict worse CR achievement. And portal vein invasion (P = 0.040), previous cTACE treatment (P = 0.030) as well as abnormal BCr (P = 0.017) were independent factor for worse ORR. In terms of OS, abnormal ALB (P = 0.011) and TBIL (P = 0.009) could independently predict unfavorable OS. The numbers of patients with abnormal ALB, TP, TBIL, ALT and AST augmented at 1-week post treatment and were similar at 1-3 months compared with baseline. Most AEs were pain, fever, vomiting and nausea, no severe AEs in this study was discovered.

Conclusions: DEB-TACE was efficient and well tolerable in treating Chinese HCC patients, and portal vein invasion, previous cTACE treatment, abnormal BCr, ALB and TBIL could be served as prognostic factors for predicting worse outcomes.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Patients (n = 275)</th>
<th>Nodules (n = 508)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR (n/%)</td>
<td>63 (22.9)</td>
<td>168 (33.1)</td>
</tr>
<tr>
<td>PR (n/%)</td>
<td>167 (60.7)</td>
<td>250 (49.2)</td>
</tr>
<tr>
<td>ORR (n/%)</td>
<td>230 (83.6)</td>
<td>418 (82.3)</td>
</tr>
<tr>
<td>SD (n/%)</td>
<td>31 (11.3)</td>
<td>60 (11.8)</td>
</tr>
<tr>
<td>PD (n/%)</td>
<td>14 (5.1)</td>
<td>30 (5.9)</td>
</tr>
</tbody>
</table>

3:45 PM Abstract No. 136

Histological findings in ex vivo and in vitro study of 75- to 150-μm and 100- to 300-μm drug-eluting beads before and after transarterial chemoembolization in liver transplant patients

M. Cura1, R. Heithaus2; 1BUMC, Dallas, TX; 2Baylor University Medical Center, Dallas, TX

Purpose: To evaluate the in vitro and ex vivo microscopic and histopathology findings of beads before administration and following liver transplantation in patients who underwent drug-eluting bead (DEB) transarterial chemoembolization (DEB-TACE) for unresectable hepatocellular carcinoma.

Materials: To evaluate the in vitro microscopic and histopathology findings of beads before administration, microscopic evaluation of a representative sample of 70-150 μm LC BeadM1™ and 100- to 300-μm DEBs (BTG, Farnham, Surrey, United Kingdom) was performed following loading with doxorubicin. Pathologic evaluation of treated livers was performed following liver transplantation in patients who underwent DEB transarterial chemoembolization (DEB-TACE) for unresectable hepatocellular carcinoma.

Results: 21 treated tumors in 19 patients were evaluated following OLT (mean tumor size 2.7 cm, r 1.4-5.0). Both in vitro, following elution of doxorubicin (mean 94.3 μm, median 100 μm, r110-70), and ex vivo, following OLT (mean 95.7 μm, median 92 μm, r126-58), evaluation of bead size demonstrates no significant size difference. Maximum vascular bead penetration within tumor vessels was seen in vessels as small as 90 μm in diameter with mean vessel size containing intact beads being 108 μm (r180-90 μm). Uniform distribution of beads within the tumor with beads penetrating the periphery of the tumor was observed. Beads were also observed in groups of 5 or more throughout the tumor vessels. Bead deformity was observed in all histologic samples, potentially a result of tissue processing. Mean bead concentration within the tumor/10 hpf was 4.75 (r11.2 – 2.6). Average tumor necrosis was 63% (r100-10%).

Conclusions: Ex vivo and in vitro evaluation of DEB s for DEB-TACE demonstrated a consistent sizing of beads providing uniform tumor coverage and distal vessel penetration within the tumors.

3:54 PM Abstract No. 137

Safety and efficacy of very small drug-eluting beads used in transarterial chemoembolization for advanced stage hepatocellular carcinoma

A Abdel Aal1, T. Tatum1, K. Mahmoud1, S. Moawad1, N. Ertel1, R. Oser1, S. Saddekni1, A. Gunn1; 1University of Alabama at Birmingham (UAB), Birmingham, AL

Purpose: The aim of this study is to evaluate the safety and efficacy of transarterial chemoembolization (TACE) in the treatment of advanced stage hepatocellular carcinoma (HCC) using very small (75μm) drug-eluting beads (DEB).
Materials: We retrospectively reviewed the medical records of 47 patients with advanced-stage HCC (BCLC C) who underwent TACE using 75um DEB as their first locoregional therapy for unresectable HCC between November 2013 and March 2016. Patients who had lesions previously treated with other TACE agents or other loco-regional therapies were excluded. Patients were evaluated for median hospital stay, 30-day adverse events, 30-day mortality, toxicity profile (using CTCAE v4.0), radiologic response (using mRECIST), progression-free survival (PFS) and overall survival (OS).

Results: The study included 36 (78.2%) males and 10 (21.7%) females with a mean age of 65.5 (SD = 9.4) years. HCV and alcoholic cirrhosis were present in 56.5% and 30.4% of the patients respectively. Child-Pugh A, ECOG 1 and portal vein invasion were seen in 71.7%, 69.7% and 19.6% of the patients respectively. Segmental TACE was performed in 91.3% of the patients. The median hospital stay was 1 day (range, 1-4). There were no 30-day mortality. There was a single occurrence of hepatic abscess. Grades 1 and 2 toxicities were seen in 21.7% of the patients. There was no grade 3, 4 or 5 toxicity recorded. Complete response, objective response and disease control were 21%, 61% and 79% respectively. The median PFS was 7.2 months. The mean OS was 14.3 months. The 6, 12 and 24 months survival were 93%, 89% and 71% respectively.

Conclusions: In this retrospective study, TACE using very small (75um) DEB is safe and effective in the treatment of patients with advanced stage HCC (BCLC C), with median PFS of 7.2 months, 2-year survival of 71%, and very low toxicity.

Transcatheter arterial chemoembolization for small (≤2cm) hepatocellular carcinoma in the caudate lobe: comparison with transcatheter arterial embolization combined with radiofrequency ablation
D. Hyun1, S. Cho1, S. Shin1, S. Bae1; 1Samsung Medical Center, Seoul, Seoul

Purpose: To analyze and compare the treatment results for small (≤2cm) HCC in the caudate lobe that was treated with TACE and combination of TACE and RFA.

Materials: Between October 2005 and February 2014, 14 patients (12 men and 2 women; mean age, 63.1 years) who underwent combination treatment of TACE and subsequent RFA and 28 patients (21 men and 7 women; mean age, 60.9 years) who underwent conventional TACE (c-TACE) for small (≤2 cm) HCC in the caudate lobe were included. Technical success, local tumor progression (LTP), progression-free survival (PFS), and overall survival (OS) were compared after propensity score matching was performed to compare baseline characteristics of TACE and COMB groups. Patient demographics and tumor characteristics were compared using t-test and Wilcoxon ranksum test for parametric variables and Fisher’s exact test for non-parametric variables. LTP, PFS, and OS were estimated with the Kaplan-Meier method and compared using Log-rank test.

Results: Propensity scoring was not significantly different between the groups. Technical success rates in TACE and COMB group were 78.6% (22/28) and 78.6% (11/14), respectively. Mean follow-up period was 57 months (range, 12 – 104 months) in TACE group and 44.7 months (range, 13.2 – 63.7 months) COMB group. The 1-, 3-, and 5-year LTP were 81.8%, 51.2%, and 51.2%, respectively, in TACE group and 100%, 90.9%, and 90.9%, respectively, in COMB group. LTP of COMB group was not significantly different from that of TACE group with selective approach (p = 0.57). The 1-, 3-, and 5-year OS were 63.6%, 15.6%, and 15.6%, respectively in TACE group and 78.6%, 37%, and 27.8%, respectively, in COMB group. The 1-, 3-, and 5-year OS were 100%, 84.6%, and 67.2%, respectively, in TACE group and 100%, 92.7%, and 83.6%, respectively, in COMB group.

Conclusions: Selective TACE seems to be as equally effective as combination treatment for small (≤2 cm) caudate lobe HCC.

4:12 PM

Abstract No. 139

Transarterial chemoembolization of hepatocellular carcinoma with a novel radiopaque drug-eluting bead
R. Lencioni1, M. Doshi1, S. Venkat1, T. Scagnelli1, G. Narayanan1; 1University of Miami Miller School of Medicine, Miami, FL

Purpose: Preclinical studies have suggested that radiopaque (RO) beads may offer advantages over standard microspheres used for transarterial chemoembolization (TACE) of hepatocellular carcinoma (HCC). The ability to image bead distribution during the procedure is expected to improve coverage of the tumor minimizing off-target delivery. We conducted a retrospective analysis of efficacy and safety of RO DEB-TACE in patients with HCC.

Materials: Forty-eight patients (38 males and 10 females, median age 64 years) with nodular, noninvasive HCC unsuitable for curative treatments, Child-Pugh A (n = 29) or B (n = 19) liver functional status, and ECOG PS 0-1 received DEB-TACE with injection of 2-4 ml of 70-150-micron RO microspheres (LC Bead LUMI; BTG-Biocompatibles UK Ltd) loaded with 37.5 mg/ml doxorubicin. Thirty-seven of 48 patients (77%) had unilobar disease and 11 of 48 (23%) bilobar tumors. The baseline sum diameter of HCC lesions was 5.3 ± 2.6 cm (range, 1.2-14.5 cm). The primary endpoint was tumor response by mRECIST. Secondary endpoints were time to progression (TTP), overall survival (OS), and safety.

Results: The number of DEB-TACE treatments was 1 in 28 patients (58%), 2 in 16 (33%), and 3 in 4 (8%). The doxorubicin dose delivered in each treatment was 43.9 ± 34.4 mg (range, 3.3-150 mg). Best response was CR, PR, SD, and PD in 32, 10, 4 and 2 patients, respectively, for an objective response rate (ORR) of 87.5%. Median TTP was 8.5 months (95% CI, 6.7-not reached). Median OS was not reached in Child class A patients; in class B patients it was 19.5 months (95% CI, 6.7-not reached). There was one treatment-emergent grade 5 AE unrelated to treatment. Grade 3/4 AEs included pain (n = 4), fatigue (n = 2), and fever (n = 1). Grade 3/4 laboratory abnormalities included thrombocytopenia (n = 9), leukopenia (n = 3), elevation of transaminases (n = 3), elevation of bilirubin (n = 3), and anemia (n = 2).

Conclusions: Treatment of HCC with RO DEB-TACE resulted in a high ORR and was well tolerated. The encouraging efficacy signal requires confirmation with long-term survival data.
Imaging and pathological outcomes of drug-eluting bead-transarterial chemoembolization for treatment of hepatocellular carcinoma using 70- to 150-μm versus 100- to 300-μm beads
E. Fayazzadeh1, A. McBride1, A. Gill1, G. McLennan1; 1Cleveland Clinic, Cleveland, OH

Purpose: To compare pathological tumor necrosis and radiological response to drug-eluting bead-transarterial chemoembolization (DEB-TACE) using 70-150 μm versus 100-300 μm beads in patients with hepatocellular carcinoma (HCC) undergoing liver transplantation.

Materials: Between September 2010 and April 2017, 31 patients with HCC received DEB-TACE (as the sole bridging modality to liver transplantation) with either 70-150 μm (n = 13) or 100-to 300-μm (n = 18) beads, loaded with a mean doxorubicin dose of ~70 mg. Patients in the 70- to 150-μm and 100- to 300-μm cohorts shared similar baseline characteristics with respect to age, gender, primary tumor diameter, Child-Pugh classification, and MELD score. Patients who had received DEB-TACE with bead size combinations were not included in the study. Index tumor response to treatment was evaluated by both the mRECIST criteria (using the last available follow-up imaging) and pathological determination of the percentage of actual tumor necrosis (using liver explants). TACE-to-imaging and TACE-to-pathology intervals were nearly equivalent among the study groups. Percentage of pathological tumor necrosis, presence of complete (100%) pathological or radiological response to treatment, and treatment failure (less than 30% pathological necrosis) were compared between the groups. Student’s t-test and Fisher’s exact test were used for analysis of continuous and categorical data, respectively.

Results: Radiological complete response, average pathological tumor necrosis, and complete pathological tumor necrosis did not prove to be statistically different among the 70-150 μm and 100-300 μm cohorts; however, the incidence of treatment failure (necrosis <30%) was significantly higher in the 100-300 μm cohort (Table).

Conclusions: DEB-TACE with larger beads (100-300 μm) may demonstrate higher rates of treatment failure. Larger multi-center studies are warranted to further elucidate the role of bead size on DEB-TACE treatment efficacy in HCC patients.

<table>
<thead>
<tr>
<th></th>
<th>70-150 μm beads (n = 13)</th>
<th>100-300 μm beads (n = 18)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiologic complete response</td>
<td>9 (69%)</td>
<td>8 (44%)</td>
<td>0.27</td>
</tr>
<tr>
<td>Average pathological tumor necrosis</td>
<td>81.54% ± 5.87%</td>
<td>64.17% ± 9.97%</td>
<td>0.18</td>
</tr>
<tr>
<td>Complete pathological tumor necrosis</td>
<td>6 (46%)</td>
<td>6 (33%)</td>
<td>0.71</td>
</tr>
<tr>
<td>Treatment failure</td>
<td>0 (0%)</td>
<td>6 (33%)</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Conclusions: Interventions resulted in significant improvement in patient delays, patient experience scores, and denied days. The invention, design, and implementation of a real-time unit-specific dashboard supplied by a data dump from the EMR was invaluable in helping to promote team awareness and transparency regarding delays and throughput.

3:09 PM Abstract No. 142

Classification of nontechnical adverse events involving interventional radiology
R. Shah1, E. McCaffrey1, L. Horwitz1, E. Aaltosen1; 1New York University, New York, NY

Purpose: To identify the most common types of nontechnical adverse events that involve interventional radiology (IR).

Materials: Retrospective review was performed of our institutional web-based error reporting system for adverse event reports involving IR from April 2010 to August 2017. Non-IR patients and technical adverse events were excluded. Remaining entries were analyzed for system factors that were categorized into five sociotechnical domains: Individual Characteristics, Nature of Work, Human-System Interfaces, Social and Environmental Conditions, and Management Resources. Each event was assigned a primary domain and a secondary domain when relevant. In addition, event outcomes were categorized as treatment delay, inappropriate care, or a near miss.

Results: 591 entries from the 88-month period were reviewed, 75 non-IR and 241 technical adverse events were excluded, leaving 275 entries for analysis and corresponding with 3.1 sociotechnical entries per month. 145 (53%) inpatient and 130 outpatient events were reported. The most problematic primary domain identified was Social and Environmental Conditions with 100 entries (36%). Within this domain, communication issues were the most commonly identified source of adverse events with 84 entries (31%). The next most common source of adverse events was Nonprocedural knowledge deficiency (63 entries, 23%) within the Individual Characteristics domain. Over half the adverse events (149, 54%) also had a relevant secondary domain, with Nature of Work (workflow and teamwork) being the most common (46 entries, 17%). With regard to outcomes, the majority of events were associated with treatment delay (149 entries, 54%) and near misses (94 entries, 34%). However, inappropriate care occurred with a significant portion of entries (32, 12%).

Conclusions: Not all IR-related adverse events are a result of technical complications. In our experience, over half of reported events can be attributed to sociotechnical factors. These factors, most commonly communication or knowledge issues, can lead to substantial negative outcomes. Building on this recognition, the next step is to design systems that eliminate or mitigate the effect of these factors.

3:18 PM Abstract No. 143

A LEAN management project in interventional radiology to improve the outpatient on time start for first cases

Purpose: A LEAN project is a set of management principles whose main principle is delivering more value with less waste. The purpose of this LEAN project was to evaluate the efficiency of on time starts of 1st cases in an interventional radiology (IR) by identifying and eliminating waste to create a reliable and sustainable outpatient on time start.

Materials: The LEAN project was initiated by the division of IR in coordination with the department of Quality and Patient Safety (QPS). An internal IR quality assurance project from January to March of 2017 demonstrated a 1.7% on time start for the first outpatient cases of the day. Start time was noted as the clinician placing the needle to patient’s skin. The QPS department coordinated a 3-day retreat to include every level of service that affects the patient’s care from arrival to needle to skin time. Services and issues included in the 3-day retreat were registration signage (hospital facilities), registration (patient financial advisory), patient preparation and initial vitals (medical assistant), nursing pre-assessment (nursing), room readiness (technologist), and clinical operators (MD, PA). During the 3-day event each service detailed their workflow on timelines from arrival to the beginning of the case. Throughout the event an Ishikawa diagram was created showing the root causes of inefficiency and potential solutions. A prioritization matrix was created, and the low effort/high return solutions were targeted for immediate implementation. Ownership to individuals for each service were assigned for monitoring of each root cause. Meetings were scheduled for solution management and maintenance.

Results: Applying the LEAN management system to an IR department allowed for defining specific target areas for improvement. Subgroup improvements were seen in prep (83% improvement), registration (73% improvement) and nursing assessment (65% improvement) which resulted in the primary improvement of outpatient 1st case start time from 1.7% to 18% (16% improvement).

Conclusions: Application of a LEAN management system to all levels of an IR department work flow can improve efficiency of outpatient 1st case start times.

3:27 PM Abstract No. 144

The effects of aprons, suspended protection systems, and mobile shields on radiation exposures to the chests and heads of interventional radiologists in clinical practice
J. Oros1, A. Lichliter1, C. Rees1; 1Baylor University Medical Center, Dallas, TX

Purpose: This study examines exposure to the chest (under-protection) and to the head when using different protection methods, utilizing recently available personal electronic dosimeter of very high sensitivity for under-protection measurements.

Materials: Two personal electronic dosimeters were worn by 7 interventionalists during normal clinical practice. Case-by-case
readings were retrospectively reviewed for a 20-month period for cases where the dosimeters were worn in the anatomic locations below. Operators wore conventional protective clothing (“Apron,” 5 non-Pb, 2 Pb) or suspended protection system (“SPS,” Zero-GravityTM, 1 mm Pb apron and arm flaps, 0.5 mm Pb face shield) combined with mobile suspended shield (MSS) per user preference and availability. The extremely sensitive Radeye GF (Thermo Scientific) was worn under-protection at the left chest where it reliably triggered despite overlying shielding. A Rad-60R (Rados) electronic dosimeter was worn at the collar, having standard sensitivity and not always triggering behind the face-shield of the SPS, but capable of giving gross estimates of “Head” exposures when used with Apron. “Chest” under protection and “Head” exposures were standardized to fluoroscopic DAP (mR*E7/mGy*cm²) and grouped by operator position at patient’s head (eg TIPS), side (eg PCN), or femoral (eg angiography). N = 469(239 SPS, 230 apron, 193 MSS, 277 no MSS), 5,223 fluoroscopy min, fDAP = 10,313,197 mGy*cm².

Results: See table. For Chest and Head: MSS vs no MSS, P = NS; Fem vs Head+Side positions, P<0.001.

Conclusions: “Side” and “Head” procedures resulted in higher exposures than “Femoral.” SPS provided significantly lower Chest and Head exposures for all operator positions. MSS had greatest effect for “Side” procedures with apron, and less effect with SPS where exposures were very low.

<table>
<thead>
<tr>
<th>Radiation Exposures</th>
<th>Chest</th>
<th>“Head”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Shield (+/-)</td>
<td>SPS</td>
<td>Apron</td>
</tr>
<tr>
<td>Apron</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Apron</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Apron</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Apron</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Operator Side</td>
<td>7.5</td>
<td>14</td>
</tr>
<tr>
<td>position</td>
<td>137</td>
<td>227</td>
</tr>
<tr>
<td>Fem</td>
<td>13</td>
<td>81</td>
</tr>
<tr>
<td>Head</td>
<td>4.0</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>6.6</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>941</td>
</tr>
<tr>
<td></td>
<td>137</td>
<td>1666</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>425</td>
<td>424</td>
</tr>
<tr>
<td></td>
<td>743</td>
<td></td>
</tr>
<tr>
<td>SPS vs. apron:</td>
<td>P&lt;0.0001</td>
<td>SPS vs. apron: P&lt;0.0001</td>
</tr>
</tbody>
</table>

3:45 PM Abstract No. 146

The use of preprocedural educational videos to augment the consenting process and increase patient understanding and satisfaction in interventional radiology

S. Koh1, S. Degerstedt1, B. Addicott2, R. Schenning2; 1Oregon Health & Science University, Portland, OR; 2Dotter Interventional Institute, OHSU, Portland, OR

Purpose: To assess the efficacy of patient education videos in the informed consent process in improving understanding and satisfaction levels for IR procedures.

Materials: Videos detailing procedural steps were created for the following procedures: tunneled central venous catheters, chest ports, TACE, IVC filters, and TIPS. Each video aims to address patient expectations and to increase preparedness. There were two cohorts in this single-blind, randomized study: Group 1 - verbal explanation of the procedure (PARQ conference) first, educational video second; Group 2 - video first, verbal explanation second. A survey was used to collect demographic data and to assess patients’ understanding and satisfaction levels (scale: 1 to 10) during the consenting and postprocedural periods. The data was analyzed using the Mann-Whitney U test for continuous variables and χ² test for categorical variables.

Results: 21 patients participated in the study: 10 randomized to Group 1; 11 to Group 2. Video education alone led to higher levels of preprocedural understanding than verbal explanation alone (P = .029). There were no preprocedural differences between the groups in any measure after receiving both educational modes. Receiving video education first led to increased intraprocedural comfort (P = .017) on postprocedural surveys (See Table 1). When doses of intraprocedural sedation medications were compared for similar procedures (N = 14, 6 TCVC and 1 port for both groups), receiving the video first showed a trend towards lower doses
**Prebiopsy labs for patients without conditions predisposing to coagulopathy: are they really necessary?**

A. Altman1, A. Wallace2, T. Jiang3, E. Okafor2, A. Lionberg1, F. Oladini2, A. Baron2, M. Matsumoto2, M. Sharma1, P. Patel1, B. Funaki1, P. Chang2; 1The University of Chicago Medicine, Chicago, IL; 2The University of Chicago, Pritzker School of Medicine, Chicago, IL; 3The University of Chicago, Chicago, IL; 4The Ohio State University, Chicago, IL

**Purpose:** To assess the frequency of abnormal INR or platelet results for all patients who underwent a core needle biopsy over a 10-year period.

**Materials:** INR and platelet parameters were retrospectively reviewed in 4,073 patients (49.0% male, 51.0% female, median age 62 years, age range 18-95 years) who underwent percutaneous core needle biopsies at our institution between 2007 and 2016. These parameters were also reviewed for 8,584 biopsies canceled. Among patients who underwent biopsy, 1,981 had one of the following predisposing condition to coagulopathy: anticoagulation therapy (608), antiplatelet therapy (931), liver disease (600), history of heavy bleeding or bleeding disorder (186), family history of bleeding (6), malnutrition (340), history of elevated INR (528).

**Results:** The average INR and platelet values are listed in the Table.

**Conclusions:** Patients with no preexisting conditions to coagulopathy rarely have abnormal INR values or platelet counts. In addition, the small percentage of all patients with abnormal INR and platelet counts suggests that it may be unnecessary for patients without preexisting conditions to undergo routine prebiopsy labs. We are currently collecting information about the preexisting conditions of all patients, as well as the approximate cost of the pre-biopsy labs, in order to make a strong statistical conclusion and perform a cost-benefit analysis.

<table>
<thead>
<tr>
<th>Table 1. Average INR and Platelet Values for Patients with and without Preexisting Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No Preexisting Conditions</strong></td>
</tr>
<tr>
<td><strong>Number</strong></td>
</tr>
<tr>
<td>Patients with INR values</td>
</tr>
<tr>
<td>Average INR</td>
</tr>
<tr>
<td>INR ≥1.5</td>
</tr>
<tr>
<td>Patients with platelet values</td>
</tr>
<tr>
<td>Average platelet count</td>
</tr>
<tr>
<td>Platelets ≤to 50,000</td>
</tr>
</tbody>
</table>

**Periprocedural bleeding risk in the setting of chronic liver disease: assessment of interventional radiologists’ practice thresholds**

W. Cheng1, J. Smirniotopoulos2, B. Logiurato3, J. Corman-Homonoff4, B. May5; 1NYP/Weill Cornell Medicine, New York, NY; 2New York Presbyterian Hospital/Weill Cornell Medicine, New York, NY; 3New York Presbyterian/A New York Presbyterian/Weill Cornell Medical Center, New York, NY; 4New York Presbyterian/Weill Cornell Medical Center, New York, NY

**Purpose:** To assess national trends in the management of periprocedural bleeding risk in the setting of cirrhosis.

**Materials:** Interventional radiologists are surveyed regarding their interpretation of the PT/INR in cirrhotic patients undergoing various image-guided procedures. Specifically, IRs are asked to specify their INR threshold for representative procedures in the setting of cirrhosis. The survey specifies that elevated INR values should be considered elevated for several months and elevated secondary to cirrhosis rather than warfarin or malnutrition. The survey specifies that the procedure is clinically indicated but not emergent. Participants are also asked which blood products, if any, they would transfuse to correct the INR. Finally, clinical experiences and current practice settings are surveyed.

**Results:** To date, 99 IRs have completed the survey. For moderate bleeding risk procedures, 51.5% report an INR threshold of 1.5 and 88.8% of respondents transfuse blood products to correct INR in
the setting of cirrhosis. For high bleeding risk procedures, 63.4% of the respondents report and INR threshold of 1.5 and 91.2% transfuse blood products to correct INR. A large majority, 87.8%, chose Fresh Frozen Plasma (FFP) to correct INR in this setting. 66% of respondents would not change their threshold if elevated INR was due to warfarin therapy as opposed to cirrhosis.

**Conclusions:** The survey results confirm an important gap in knowledge among a majority of practicing IRs with respect to the INR test and cirrhosis. While the responses are in keeping with general SIR guidelines, cirrhosis presents a unique population in whom elevated INR values do not predict bleeding risk. Cirrhosis results in rebalanced hemostasis with normal clotting potential despite elevated INR, unlike INR elevation secondary to warfarin therapy or malnutrition. Furthermore, FFP transfusion is not recommended in cirrhosis to correct INR since it exacerbates portal hypertension and has not shown to reduce bleeding despite normalizing INR. This survey suggests that significant education of the IR community is necessary to improve this outdated practice pattern that carries risk without benefit.

**4:12 PM Abstract No. 149**

**Development of an automated system for quality assurance of image-guided biopsies**

J. Chen1, D. Lalevic1, X. Zhang1, J. Wildenberg1, S. Trottola2, T. Cook1, 1University of Pennsylvania, Philadelphia, PA; 2University of Pennsylvania Medical Center, Philadelphia, PA

**Purpose:** Quality assurance (QA) of image-guided biopsies is an important but often inefficient process which can require manual query of data from disparate electronic records. The purpose of this project was to develop an automated platform to improve biopsy QA efficiency by aggregating procedure, pathology, and complication data.

**Materials:** Automated scripts were used identify biopsy reports from an institutional Powerscribe 360 database by exam code and text parsing. Pathology reports were queried from an institutional Epic database by medical record number and biopsy date. Complications were assessed from biopsy reports and a HI-IQ database.

Query results were joined using structured query language (SQL) scripts and stored in a MySQL database. A web frontend for data entry and display was developed using Javascript Bootstrap. On a monthly basis, data from the automated system were compared with manual QA data to assess sensitivity for identifying biopsy and pathology results. The time required for QA using manual methodology and the automated system was compared.

**Results:** Between 1/1/2017 and 6/30/2017, 331 biopsies underwent QA, of which 16 (4.8%) were non-diagnostic, and 8 (2.4%) had complications. The automated biopsy QA system captured 3 (1%) biopsies which were not identified using manual query and missed 1 (0.3%) biopsy which was performed during renal mass cryoablation and not coded as a biopsy nor described in the report text. In addition to 24 dedicated biopsy exam codes, the automated query was expanded to 33 exam codes for non-biopsy procedures during which a biopsy may be concurrently performed. Parsing for the term “biopsy” among the report text was effective in identifying relevant studies among these procedures. The mean time required to QA one month of biopsies decreased from 4.8 hours (n = 4) using manual method to 1.5 hours (n = 4), p = 0.0002, using the automated system.

**Conclusions:** An automated biopsy QA system can reliably aggregate radiology, pathology, and complication data from separate electronic sources to improve QA efficiency.

**4:21 PM Abstract No. 150**

**Percutaneous cholecystolithotomy: missed opportunity in interventional radiology?**

J. Su1, J. Watchmaker1, J. Aquino2, T. Borgmann2, C. Baron4, F. Banovac4, L. Stokes4, R. Muller4, P. Bream2, D. Brown2, 1Vanderbilt University, Nashville, TN; 2Vanderbilt University Medical Center, Nashville, TN

**Purpose:** To identify and compare national utilization trends of percutaneous cholecystostomy (PERC), open (OP) and laparoscopic (LAP) cholecystectomy, and cholecystolithotomy (CYSTO) in Medicare recipients between 2000 and 2015.

**Materials:** Using Medicare fee-for-service data from the Medicare Physician/Supplier Procedure Summary Master Files, the number of gallbladder procedures performed between 2000 and 2015 was determined and trends were compared. Data were chosen via Current Procedural Terminology (CPT) codes for PERC (47,490), OP (47,600, 47,605, 47,610, 47,612, 47,620), LAP (47,562, 47,563, 47,564) and CYSTO (47,630, 47,544). Changes in procedure volumes over time were measured using linear regression with p < 0.05 considered significant.

**Results:** The number of percutaneous PERC performed increased 429% from 1,925 to 10,184 (R2 = 0.99; p < 0.0001) while total number of surgical cholecystectomies decreased 19% from 259,656 to 209,137. OP decreased 72% from 61,978 to 17,376 (R2 = 0.98; p < 0.0001) while LAP decreased 3% from 197,678 to 191,761 (R2 = 0.25; p = 0.0515). CYSTO decreased 57% from 867 to 293 (R2 = 0.95; p < 0.0001).

**Conclusions:** The number of PERC performed annually on Medicare beneficiaries has significantly increased while OP and LAP have both decreased. The decrease in CYSTO in light of the decreased resection rate raises questions regarding stone patients who may require lifelong drainage. These trends suggest an opportunity for interventional radiology to improve patient quality of life.
Safety and efficacy of angioplasty and/or stenting for transplant renal artery stenosis

A. Sethi¹, V. Madhusoodanan², J. Salsamendi³, P. Mohan⁴, ¹University of Miami, Miami, FL; ²N/A, Miami, FL; ³N/A, Pinecrest, FL; ⁴University of Miami Miller School of Medicine, Miami, FL

Purpose: Transplant renal artery stenosis (TRAS) is a complication that becomes evident within 3 months to 2 years of transplant. The most common location is the anastomotic site, which can lead to allograft failure, refractory hypertension and fluid retention. Percutaneous transluminal angioplasty is the mainstay of treatment. The aim of this study is to assess the safety, technical factors and efficacy of angioplasty and/or stenting in TRAS.

Materials: This is a single-center retrospective study of all cases of transplant renal artery angioplasty/stenting from 2015-17. Using CPT codes, 81 cases were retrieved, of which 21 cases were selected for the study. Data was retrieved from electronic medical records and PACS. Paired sample t-tests were used for statistical analyses. CO2 contrast was used for all angiography except for the final measurement angiogram prior to and during stent placement. Iodinated contrast volume was restricted to less than 10 mL in all cases. One case was done with CO2 alone.

Results: Out of 21 patients, 12 were females and the mean age was 58.9 years (SD 8). Angioplasty alone was done in 9 patients and stenting was done in 12 patients. Mean angioplasty balloon diameter was 4 mm. Mean stent diameter was 4.7 mm. The mean peak systolic velocity (PSV) in the renal artery prior to intervention was 443.7 cm/s (SD 104.0) which decreased to 250.2 cm/s (SD 134.4) at a follow-up duration within one month (p<0.001). The mean creatinine prior to intervention was 2.83 mg/dL (SD 1.2) which decreased to 1.81 mg/dL (SD 1.04) at a follow-up duration within 6 weeks (p<0.001). The mean decrease in PSV was 43% (SD 24.5) and the mean fall in creatinine was 35.2% (SD 18.3). The mean improvement in stenosis and the improvement in creatinine or PSV (p=0.38 and p=0.47 respectively). There were no complications experienced with any of the 21 patient interventions.

Conclusions: Angioplasty and stenting is a safe and effective treatment for transplant renal arterial anastomotic stenosis, which significantly improves blood flow and renal function with minimal use of iodinated contrast agents.

Predictors of all-cause mortality after endovascular aneurysm repair

T. Huber¹, N. Keefe¹, J. Patrie¹, L. Wilkins²; ¹University of Virginia, Charlottesville, VA; ²University of Virginia, Charlottesville, VA

Purpose: Endovascular aneurysm repair (EVAR) has allowed for treatment of older patients with more comorbidities. As more focus is placed on patient outcomes and quality, better risk stratification tools are needed for preprocedural planning in IR. Previous studies have associated core muscle size with postoperative mortality for
transcatheter aortic valve repair, open aneurysm repair, and endovascular aneurysm repair. The current study evaluated multiple variables including core muscle size, BMI, age, and Charlson comorbidity index (CCI) as predictors of all-cause mortality after EVAR.

**Materials:** An IRB approved single-center retrospective study of patients with a history of EVAR between 2010 and 2016 was performed. After excluding patients without preprocedure cross-sectional imaging and those incomplete medical records, a total of 407 patients were included. The total psoas muscle area (TPMA) was measured in cross-section at the superior endplate of L4. Kaplan-Meier curves were constructed for each of the candidate variables. Univariate and multivariate analyses were performed to determine which variables were significant predictors of mortality.

**Results:** Mean follow-up time was 38.7 months (SD 33.5 months). Following endovascular repair, there was a significant difference (p<0.002) in mean survival time for patients with total psoas muscle area smaller than 1422 mm² (the lowest quartile); 63.7 months (SE 4.4 months) compared to 90.3 months (SE 4.0 months) for patients with TPMA greater than 1422 mm². The mean survival time for patients who were underweight was 38.1 months (SE 14.8 months); significantly different from normal, overweight, and obese patients, p<0.015. Multivariate analysis demonstrated that total psoas muscle area and BMI were significant predictors of mortality after EVAR (p<0.006 and p<0.012, respectively). Other variables such as age, gender, and CCI were not significant.

**Conclusions:** Significant predictors of all-cause mortality after EVAR included BMI and TPMA. Age, gender, and Charlson comorbidity index were not significant predictors in the multivariate model. Therefore, inclusion of BMI and core muscle size in risk stratification tools may identify truly frail patients.

---

**3:36 PM Abstract No. 155**

**Bare-metal, covered, and drug-eluting stent patency following recanalization of femoropopliteal chronic total occlusions**

K. Narsinh¹, K. Dortche¹, A. Brandis², J. Redmond², T. Clark²; ¹University of Pennsylvania, Philadelphia, PA; ²Penn Presbyterian Medical Center, Philadelphia, PA

**Purpose:** Drug-eluting and covered stents have shown increased patency over angioplasty for femoropopliteal disease. However, limited data exist for whether these benefits extend to chronic total occlusions, and their incremental benefit when compared to bare-metal stents. The purpose of this study is to compare long-term patency of bare-metal, covered and drug-eluting stents following recanalization of femoropopliteal chronic total occlusions.

**Materials:** A retrospective review was performed of all patients undergoing subintimal recanalization of femoropopliteal chronic total occlusions between January 2010 and June 2017 (n = 59 limbs in 56 patients). Primary, assisted primary, and secondary patency was compared among three groups: 1) bare-metal (SMART, Cordis; LifeStent, Bard; or Zilver 635, Cook) 2) PTFE-covered (Viabahn, Gore) and 3) drug-eluting stents (Zilver PTX, Cook).

**Results:** Patient demographics were similar between the three groups (70 ± 12 years of age, 41% male, 66% with critical limb ischemia (CLI), lesion length = 15 ± 7.6 cm). CLI patients with below-knee occlusive disease underwent tibial revascularization during the same encounter to establish in-line flow to the foot. Median primary assisted patency for drug-eluting stents (394 days; n = 25 limbs) and covered stents (455 days; n = 18 limbs) was significantly longer than for bare-metal stents (151 days; n = 17 limbs) by log-rank test (p = 0.03). Median primary assisted patency was also higher for drug-eluting stents (430 days) than for bare-metal stents (304 days). Secondary patency was also higher for drug-eluting stents (100% at 400 days) and covered stents (91% at 400 days) compared to bare-metal stents (58% at 400 days).

**Conclusions:** Long-term patency of drug-eluting and covered stents used for recanalization of chronic femoropopliteal occlusions appears equivalent, and significantly better than patency of bare-metal stents.
Angiographic predictors of successful limb salvage in patients with critical limb ischemia: interim 6-month outcomes
K. Zhuang1, F. Irani1, A. Patel1, S. Leong1, W. Ni2, K. Tay1; 1Singapore General Hospital, Singapore, Singapore; 2Duke-National University of Singapore Medical School, Singapore, Singapore

Purpose: To correlate the number of crural run off vessels and plantar arch integrity on completion angiography with limb salvage in patients with critical limb ischemia (CLI) who underwent percutaneous transluminal angioplasty (PTA) as first line treatment.

Materials: A retrospective study analyzing 1968 patients who underwent 3303 PTA procedures in 2402 limbs for CLI in Singapore General Hospital between 2005 and 2015 was performed. The mean age of the patients was 68 ± 11 years old and 1057 (54%) patients were male. Significant comorbidities include diabetes mellitus in 88% and end-stage renal failure in 29%. The majority of the patients (2989 cases, 90%) had tissue loss (i.e. Rutherford 5-6).

Results: The limb salvage rates were 73%, 71%, 69% and 60% at 1,3,5 and 10 years respectively. Limb salvage rates at one year for 0, 1, 2 and 3 crural runoffs were 48%, 69%, 77% and 78% respectively. The 1-year limb salvage rates for absent, partial and complete plantar arch were 49%, 71% and 81% respectively. At least 1 crural runoff was needed for limb salvage (0 vs. 1 vessel: p<0.001). Achieving 2 crural runoffs correlated with improved limb salvage rates compared to 1 crural runoff (1 vs. 2 vessels: p = 0.01). The presence of 3 crural runoffs did not improve limb salvage (p = 0.358) compared to 2 crural runoffs. Patients with complete plantar arch have statistically better limb salvage rates compared to partial (p = 0.002) or absent (p<0.001) plantar arches. In patients with a complete plantar arch, there was no difference in limb salvage rates regardless of whether there was 1, 2 or 3 crural runoffs (1 vs. 2 vessels: p = 0.446, 2 vs. 3 vessels: p = 0.524).

Conclusions: Achieving 2 crural runoffs had improved limb salvage compared to 1 vessel runoff while an additional third crural runoff did not further improve limb salvage. Limb salvage rates were similar regardless of the number of crural runoffs in patients with complete plantar arch, suggesting that achieving a single crural runoff was sufficient in this group of patients.
30 days due to pneumonia and 3 of the patients expired past 30 days; one due to cardiac arrest, and the two due to bleeding not related to their interventions. Our technical success rate for inline flow recanalization was 96.8%. Four patients had below-the-knee amputations at 2 months. Two patients had above-the-knee amputation, one is at 1 month and other one is at 6 months after their first below-the-ankle intervention. Overall limb salvage rate was 88% with an average follow-up duration of 16.7 months (1 to 43 months).

**Conclusions:** Below ankle recanalization interventions are technically feasible and mid-term clinical outcomes are favorable. A randomized clinical trial may help to further identify role of below-the-ankle interventions in improving limb salvage rates.

---

**Technical feasibility and safety of left distal transradial access for percutaneous image-guided procedures**

A. Hadjivassiliou¹, J. Chung¹, D. Liu¹, D. Klass¹; "University of British Columbia, Vancouver, BC

**Purpose:** To assess technical feasibility and safety of left distal transradial access in the anatomical snuffbox for percutaneous image-guided procedures.

**Materials:** A retrospective analysis during 2016 – 2017 was performed at our tertiary institution.

**Results:** A total of 43 patients (34 males, 9 females), aged between 38 – 85 years (mean 64.2) were included. The procedures performed were hepatic chemoembolizations (n = 28), visceral embolizations (n = 5), diagnostic angiography (n = 5), internal radiation therapy with Yttrium-90 (n = 3), surgical arteriovenous fistula closure (n = 1) and iliac aneurysm embolization (n = 1). The left radial artery size on ultrasound measured between 1.4 – 3.2 mm at the wrist and 1.4 – 2.7 mm at the anatomical snuffbox (mean 2.4 ± 2.2; p = 0.2431). INR range 0.9 – 2.8 (mean 1.6), platelets 37 – 306 × 10⁹/L (mean, 143). Sheath size used was 4 Fr or 5 Fr (Prelude Ease; Merit Medical, South Jordan UT). The technical success rate was 100%, a single grade 1 hematoma occurred in the first patient (1/43; 2.3%), no radial artery occlusions were encountered.

**Conclusions:** The left radial artery size at the anatomical snuffbox is not significantly different than at the wrist and can be accessed without added technical difficulty. The distal approach carries a lower risk for potential radial artery occlusion than conventional radial access, it is suitable for patients with clotting abnormalities and improves patient comfort as it allows movement at the wrist during postprocedural hemostasis. To date, this technique has not been published in the literature. Our data supports that left distal transradial access is feasible, safe and can be utilized as an access site for percutaneous image-guided procedures.

---

**Endovascular management of acute mesenteric ischemia**

A. Hsu¹, K. Bhattacharya¹, H. Chan¹, B. Gardner¹, T. Huber¹, J. Stone¹, J. Angle¹; ¹University of Virginia, Charlottesville, VA

**Purpose:** The mortality rate of acute mesenteric ischemia (AMI) is 50-70% and up to 90% in the case of bowel infarction [1]. Patient survival is contingent on revascularization before ischemia progresses to intestinal gangrene [2]. Although abdominal exploration followed by vascular bypass was the standard of care, there is increasing use of endovascular treatment of mesenteric artery disease followed by selective exploratory laparotomy (ex-lap).

**Materials:** Retrospective procedural database review at one institution of patients who underwent mesenteric artery angioplasty or stenting (with or without thrombectomy or thrombolysis) from 2010 to 2017 in the setting of AMI revealed 30 patients. Imaging and key clinical measures were collected from the medical records.

**Results:** Technical success, defined as the ability to open at least one vessel, was 100% (30/30). Stents were placed in 25/30 patients. Overall 30-day survival was 60% (18/30). Patients who did not undergo an ex-lap had an 83.0% (10/12) survival, while patients who received laparotomy after endovascular reperfusion had a 60.0% (6/10) survival. Patients who underwent an ex-lap before reperfusion had a 25.0% (2/8) survival (p = 0.077). There were no significant differences in lactic acid levels between the no ex-lap, prerereperfusion, and post-reperfusion ex-lap groups (mean 2.65, 3.51, and 2.02 mg/dl, p = 0.357). The prereperfusion ex-lap group, however, had a longer time to reperfusion than the post-reperfusion ex-lap group (8475 mins vs. 3049 mins, p = 0.009). Other factors that contributed to 30-day survival include: bowel surgery, sepsis, lactic acidosis, and revisits to the operating room (p<0.05). Procedure-related complications were seen in 20% of patients (6/30).

**Conclusions:** Survival in those managed with endovascular reperfusion, particularly those who can avoid ex-lap, is higher than historical controls. This suggests that time to reperfusion along with the need for, and timing of, ex-lap before or after endovascular treatment play an important role in predicting the survival of AMI patients. Further study is needed into patient selection and when ex-laps should be performed.
percutaneous transhepatic biliary drainage (PTBD) may be more appropriate in this setting [1]. The purpose of this study is to identify the influence of cholangiocarcinoma location on therapy outcomes.

**Materials:** Records of 122 patients with newly diagnosed cholangiocarcinoma requiring biliary decompression from 2007 to 2016 were retrospectively reviewed. Preprocedural MRI was used to classify tumor location for 84% of patients. When this was not available, fluoroscopic procedural images were used. Hilar cholangiocarcinoma (Klatskin tumor) was present in 74 patients, and 41 had tumor involving the common hepatic and/or common bile ducts but not the hilum. PTBD was the initial therapy for 57 patients, and 65 were initially treated by ERCP. Therapeutic success was defined as resolution of hyperbilirubinemia to below 2.5 mg/dL, a level at which systemic chemotherapy can be safely administered.

**Results:** Of the group receiving initial ERCP treatment, 18/33 (55%) patients with hilar cholangiocarcinoma required conversion to PTBD within 30 days, compared to 4/28 (14%) with cholangiocarcinoma of the common hepatic or common bile ducts. Patients with hilar tumors are therefore over three times more likely to fail endoscopic management (p = 0.001). Immediately apparent technical failure of ERCP stent placement occurred in 9/33 (27%) patients with hilar tumors. The ERCP and PTBD treatment groups had average pretreatment serum total bilirubin concentrations of 17.5 and 17.4 mg/dl, respectively. In both treatment groups, half of the patients reached therapeutic success within the period of available follow-up data. The PTBD group had a shorter mean time to therapeutic success of 33 days vs. 41 days for the ERCP group.

**Conclusions:** Hilar location of cholangiocarcinoma is a strong predictor of failure of endoscopic management. PTBD as the first-line therapy for these patients could minimize the number of procedures performed and the associated complication risks. MRI is useful to determine which treatment best suits a patient.

**3:09 PM Abstract No. 161**

Percutaneous common bile duct stone removal via percutaneous cholecystostomy and cystic duct cannulation: technical outcomes and factors influencing the result in 114 patients

J. Yun1, G. Jung1, J. Park1, Y. Kim2; 1Kosin University Gospel Hospital, Busan, Republic of Korea; 2Andong General Hospital, Gyeongbuk, Republic of Korea

**Purpose:** To evaluate the technical outcomes of percutaneous transcholecystic removal of common bile duct (CBD) stones and to identify predictors of technical failure in patients with cholangitis and/or cholecystitis.

**Materials:** From September 2011 to February 2017, 114 consecutive patients (68 men, 46 women; age range, 30–95 years; mean age, 73 years) with CBD stones underwent percutaneous stone removal via cholecystostomy and cystic duct cannulation. All patients had acute cholangitis and/or cholecystitis. All patients could not tolerate immediate surgery due to cardiac problem (n = 42), previous cancer operation (n = 23), or poor medical condition including sepsis (n = 11), pulmonary dysfunction (n = 11), diabetes mellitus (n = 18), or liver cirrhosis (n = 9). The stones were extracted through the 12-Fr sheath using a Wittich nitinol stone basket under fluoroscopic guidance. The technical success rates and complications were evaluated. Logistic regression analysis was used to identify predictive factors of technical failure.

**Results:** CBD stones were successfully removed in 94 of the 114 patients (82%). In 20 patients, stone removal was failed due to failure of cystic duct cannulation (n = 12), multiple CBD stones (n = 3), proximal migration of CBD stone (n = 4), and low insertion of cystic duct (n = 1). Stone removal was performed within a maximum of 16 days (mean 4.5 days) after the percutaneous cholecystostomy procedure under conscious sedation. The mean time for removal of cholecystostomy catheter after successful stone extractions was 7.1 days. No procedure related major complications were seen. During the mean follow-up of 644 days, recurrence of CBD stone occurred in 12 patients 439-1799 days (mean, 884 days) after the procedure. Failure of cystic duct cannulation and proximal migration of the CBD stone were identified as independent predictors of technical failure.

**Conclusions:** Percutaneous CBD stone removal through the percutaneous cholecystostomy route is safe and technically feasible. Failure of cystic duct cannulation and proximal migration of the CBD stone were independent predictors of technical failure.

**3:18 PM Abstract No. 162**

Formula to predict reduction of total bilirubin underestimates success in malignant obstruction patients at a tertiary care center

A. Khosla1, L. Chan2, I. Idakoji3, G. Hwang4; 1Stanford, Mountain View, CA; 2Stanford Medical Center Department of Radiology, Stanford, CA; 3Stanford University Medical Center, Menlo Park, CA; 4Stanford University, Hillsborough, CA

**Purpose:** A previous study showed a formula (BIAL) predicts reduction of total bilirubin (Tbil) following percutaneous drainage. This study attempts to validate if that score is predictive in a separate tertiary care population.

**Materials:** Single-center retrospective study of patients who underwent biliary drain placement between 2009 and 2015 for non-cholangitic malignant biliary obstruction; of 208 patients, 41 had relevant lab data for retrospective analysis. Predicted post-placement total bilirubin (PoTbil) was calculated using the BIAL formula: \[ \log (PoTbil) = 0.205 + 0.844 \cdot \log (PreTbil) + 1.13 \cdot \log (INR) - 0.198 \cdot \log (ALT) \]. Successful drainage was defined as PoTbil \( \leq 2 \) mg/dL. PoTbil was assessed at both 30 days and the range of available data (median 37 d, range 3 to 309).

**Results:** BIAL predicted PoTbil \( \leq 2 \) in 6 patients (15%) and PoTbil > 2 in 35 patients (85%). When all post-drainage data was evaluated, the prediction was correct in 20 patients (49%); 5 (12%) achieved predicted PoTbil \( \leq 2 \) and 15 (37%) achieved predicted PoTbil > 2. In 20 patients who achieved PoTbil \( \leq 2 \) (49%), BIAL incorrectly predicted drainage failure. In 1 patient (2%), BIAL incorrectly predicted drainage success. Sensitivity was 20% and negative predictive value was 43%. BIAL prediction was more accurate if follow-up was limited to 30 days: BIAL prediction was correct in 5/11 patients who achieved PoTbil \( \leq 2 \) in 30 days (45%); the remaining 6 (55%) were not predicted to reach PoTbil \( \leq 2 \). At 30 days, BIAL correctly predicted PoTbil \( \geq 2 \) not reaching the target level in 29 of the remaining 30 patients. Yielding sensitivity of 45% and negative predictive value of 83%.
Conclusions: BIAL underestimated the likelihood of successful drainage in a malignant biliary obstruction population: for maximum follow-up, 60% of patients achieved PoTbil ≤2 versus the predicted 15%; at 30 days, 27% reached PoTbil ≤2 versus the predicted 12%. This suggests that BIAL may not be applicable across patient populations, and repeat analysis will be needed with pooled populations to create a more universal model to determine biliary drain placement success.

3:27 PM Abstract No. 163

Risk predictive nomogram for early biliary infection in patients with malignant biliary obstruction underwent percutaneous transhepatic biliary stenting: based on the preprocedure factors
H. Zhou1, H. Zhu1, J. Lu1, B. Zhong1, J. Guo1, G. Teng1; Zhongda Hospital, Southeast University, Nanjing, China

Purpose: We aimed to identify the independent risk factors for early biliary infection (EBI) after percutaneous transhepatic biliary stenting (PTBS) of malignant biliary obstruction (MBO) patients and establish an early predictive nomogram.

Materials: Between January 2012 and December 2016, patients who were treated with PTBS for MBO in three clinical centers were enrolled. Patients were observed within 30 days after stenting, who were divided into the infected group and non-infected group. The characteristics of patients with EBI were evaluated and compared with those of patients without EBI. The independent risk factors for EBI after PTBS were identified by multivariate logistic regression analysis from the risk factors selected by univariate analysis and used to develop the nomogram to predict the probability of post-stenting EBI.

Results: Finally, 182 patients were included in this study. The univariate analysis showed digestive surgeries or ERCP history, acid-inhibitor use, diabetes, gallstones, length of obstruction, location of obstruction and preprocedure PTBD were the potential risk factors related to EBI. Multivariate regression analysis showed that length of obstruction, diabetes, high level obstruction, digestive surgeries or ERCP history were the independent risk factors. Then, the risk predictive nomogram was established based on these four independent risk factors with the c statistic of 0.79.

Conclusions: The predictive nomogram was established successfully based on the four preprocedure factors: length of obstruction, diabetes, high level biliary obstruction and digestive surgeries or ERCP history. It may help to earlier estimate the risk for EBI in patients with MBO underwent PTBS.

3:36 PM Abstract No. 164

The addition of paclitaxel coated balloon cholangioplasty for the treatment of benign biliary strictures: a single-center experience
J. Elbich1, T. Nobbee2, J. Widdicombe3; 1VCU Health Systems, Richmond, VA; 2VCU School of Medicine, Chesterfield, VA; 3N/A, Prince George, VA

Purpose: There has been histologic evidence that benign biliary strictures are caused by a chronic inflammatory reaction involving myofibroblasts with smooth muscle characteristics leading to contraction and fibrosis. Paclitaxel coated balloons (PCB) have been used to reduce myofibroblast activity in other settings, notably arteries. The purpose of this study was to evaluate the utility of adding PCB to standard cholangioplasty treatments of benign biliary strictures.

Materials: An IRB approved retrospective chart review was performed on patients with benign biliary strictures treated with PCBs between 2014 and 2016 with minimum one-year follow-up. Patient characteristics including age, stricture pathology, treatment types, treatment dates, and follow-up outcomes information were collected. 13 patients (5 men, 8 women; mean age, 54.3 years; range, 35-73) completed the treatment protocol of PCB cholangioplasty in addition to high pressure and cutting balloon cholangioplasty. 12 patients had a surgical etiology (4 liver transplants, 8 cholecystectomies, 1 other), and 1 patient had a benign stricture due to chronic pancreatitis.

Results: 12 of the 13 (92.3%) went on to percutaneous drain removal. The average number of treatments with PCBs before drain removal was 2.6 (median 2; range 1-4). The mean time between initial cholangioplasty and drain removal was 112.75 days. The 1 patient (7.7%) that could not have the drain removed has had a percutaneous biliary drain in place for more than 12 years for a recalcitrant stricture. 11/12 (91.7%) patients were intervention free 1 year after drain removal. Beyond 1 year, 3 additional patients did require reintervention for obstruction. Regarding the cholangioplasty procedures, there were no major complications.

Conclusions: This retrospective study demonstrates encouraging results for the utility of adding paclitaxel drug-coated cholangioplasty in the treatment regimen for benign biliary strictures, specifically in the time to drain removal and the 1-year freedom from reintervention. As this is a single-arm single-center experience, further study will be required.

3:45 PM Abstract No. 165

Biodegradable biliary stents for benign biliary anastomotic strictures: preliminary results and short-term outcomes
M. Arabi1, B. Alrehaili1, S. Qazi1, O. Bashir1, R. Salman1, M. Al-Moaqiel1; 1King Abdulaziz Medical City, Riyadh, Saudi Arabia

Purpose: Assess the effectiveness of Biodegradable biliary stents in the management of benign anastomotic biliary strictures refractory to cholangioplasty and biliary drainage.

Materials: This is a retrospective study of consecutive patients who underwent biodegradable stent placement for benign anastomotic biliary strictures since July 2016. Eight patients (6 males) were included with mean age of 53 years (23-72 years). Six patients had liver transplant (4 choledochocoleodochal anastomosis, 2 hepaticojejunral anastomosis). Two patients had primary sclerosing cholangitis with hepaticojejunral anastomosis. The mean time since surgery was 4.4 years. All patients had anastomotic strictures managed by percutaneous biliary drainage prior to stent placement. Six patients had previous (1-4) sessions of biliary dilatation. Two patients preferred stent placement to avoid long-term tube dependence.

Results: Eight patients received a 10-mm x 40-mm Ella biodegradable stent at the anastomosis. One patient died 2 month later due to progressive liver cirrhosis. Five patients required no reintervention at mean follow-up time of 232 days (96-322 days). Two liver transplant patients required reintervention. One patient with
hepaticojejunostomy had biodegradable stent re-insertion after 214 days and ultimately had recurrence of strictures after 84 days after the second intervention. One transplant patient with choledochocholedocal anastomosis presented after 143 days with recurrent obstructive jaundice due to sludge, which was managed by endoscopic plastic stent placement. There was one major procedure related complication (cholangitis and sepsis) and one minor complication (limited septicemia). No procedure related mortality. The two patients who required reintervention had partial or complete stent dissolution at the time of recurrence.

**Conclusions:** Biodegradable biliary stent may offer a safe and effective option to avoid tube dependence and prolong time-to-reintervention in patients with benign anastomotic biliary strictures.

---

**Abstract No. 166**

WITHDRAWN

---

**3:54 PM**

**Abstract No. 167**

**Long-term results of percutaneous biliary balloon dilatation and sequential upsizing of silastic transanastomotic stents for benign hepaticojunostomy strictures: a tertiary care center experience**

K. Nagabhushan¹, J R², M. Thumu², K. Sunilkumar²; ¹Asian Institute of Gastroenterology, Hyderabad, India; ²Asian Institute of Gastroenterology, Hyderabad, Telangana

**Purpose:** To determine the safety, efficacy, and long-term results of percutaneous biliary balloon dilatation (PBBD) and sequential upsizing of Silastic Transanastomotic stents (STS) for benign HJ strictures.

**Materials:** PBBD was performed after traversing HJ strictures, followed by placement of STS from both right and left ductal system or both from right ductal system. These silastic catheters were fashioned as transanastomotic stents and were upsized sequentially with a larger bore over a period of one year at 3 months interval. Two patients had undergone retrograde placement through transjejunal puncture. A total of 135 patients (59 male, 76 female; age range, 6-71 year; mean age 41.64 year), who had undergone HJ were recruited for study between 2007-2014. Mean maximum diameter achieved at the end of one year 34.3 French. Mean procedure time and mean Fluoroscopic time were 49.5 minutes (31-64 minutes) and 15.33 minutes (13.6- 18.2 minutes). Cholangiograms, Balloon Manometric Perfusion tests or spy cholangiography were done before removal of STS to ensure adequate decompression of strictures. The primary outcome measure was the absence of clinical biliary obstruction symptoms at 24 months.

**Results:** The overall Technical and clinical success rates were 98.5 and 97.7%, respectively. The primary outcome measure was achieved in 98.5% of patients respectively. The mean follow-up period and mean primary patency durations were 43.15 months and 42.76 months. Procedure-related mortality and major morbidity rates were 0% and 3.7%, respectively. Weight gain by the patients during upsizing in a year was significant $p = 0.001$.

**Conclusions:** PBBD and sequential upsizing of silastic transanastomotic stents for benign HJ strictures is a safe and effective procedure with excellent outcome measures.

---

**4:03 PM**

**Abstract No. 168**

**Results of percutaneous cholecystostomy tube placement in 324 patients**

J. Bundy¹, R. Srinivasa², J. Gemmeste³, A. Hage⁴, B. Majdalany⁵, W. Saad⁶, J. Chick⁷; ¹N/A, Grand Rapids, MI; ²University of Michigan Medical Center, Ann Arbor, MI; ³University of Michigan Hospitals, Northville, MI; ⁴University of Michigan, Ann Arbor, MI; ⁵University of Michigan Health System, Ann Arbor, MI

**Purpose:** Determine the technical success and clinical outcome of cholecystostomy tube placement along with removal rate after placement.

**Materials:** A database search was performed from January 2010 to September 2017 for the term “cholecystostomy tube” yielding 1,160 patients. Patients with no indication for cholecystostomy (n = 625; 53.9%) or an outside hospital placed cholecystostomy (n = 211; 18%) were excluded. 324 (27.9%) patients with cholecystostomy tubes were included in the analysis. 312 (96.2%) tubes were placed by interventional radiology and 12 (3.8%) intraoperatively by surgery. Indication for cholecystostomy tube placement, ultrasound findings, initial lab studies, candidacy for surgery, comorbidities, access route, tube size, dwell time, bile culture results, reason for tube removal, follow-up, and complications were recorded.

**Results:** The indications for cholecystostomy tube placement included: acute cholecystitis (n = 270; 83.3%), perforated cholecystitis (n = 22; 6.8%), and emphysematous choledocholithiasis (n = 18; 5.6%). Ultrasound findings included: wall thickening (n = 208; 64.2%), calculi (n = 187; 57.7%), and pericholecystic fluid (n = 143; 44.1%). 297 (91.7%) patients were not surgical candidates. The most frequent reason for removal was cholecystectomy (n = 96; 29.6%). 36 (11.1%) had a patent cystic duct on follow-up, 19 (5.9%) had cholecystoscopy and stone removal, 15 (4.6%) underwent double J stent placement, and 3 (0.01%) had liver transplants. 94 patients died (29%), 33 (10.2%) died tubes migrate or fall out. 256 (79%) had transhepatic and 56 (17.2%) had transperitoneal tubes. Mean tube size was 7-French. Mean dwell time was 89 days (range, 0-586 days). 45 (13.9%) patients had tubes at the end of study period, and 19 (4.2%) were lost to follow-up, 13 (28.9%) had ongoing tube changes, 8 (17.8%) scheduled cholecystectomy, and 4 (8.9%) getting downsized with plans for removal. 321 (99%) of patients had no major adverse events, 2 (0.006%) had bile leak, and 1 (0.001%) developed septic shock.

**Conclusions:** Cholecystostomy tube placement was possible in all patients and clinical symptoms resolved after placement in all cases. A majority of patients were able to have their tubes removed.

---

**4:12 PM**

**Abstract No. 169**

**Medium- and long-term follow-up of benign biliary strictures treated with biodegradable stent**

J. Guirola Ortiz¹, S. Wong Kant², M. Sanchez Ballestin¹, J. Bosch Melguizo¹, C. Serrano Casarrian¹, E. Criado Paredes³, M. De Gregorio⁴; ¹GITMI, Zaragoza, Zaragoza; ²GITMI, Zaragoza, Zaragoza; ³Corporació Sanitària i Universitària Parc Taulí (Sabadell), Sabadell, Barcelona; ⁴Universidad De Zaragoza, Spain, Zaragoza, Spain

**Purpose:** To report the medium- and long-term results of endoscopic plastic stent placement. There was one major procedure related complication (cholangitis and sepsis) and one minor complication (limited septicemia). No procedure related mortality. The two patients who required reintervention had partial or complete stent dissolution at the time of recurrence.
Purpose: Determine the feasibility and efficacy of a biodegradable biliary stent in the treatment of benign strictures of the biliary tract by the implantation of ELLA type stent with medium and long-term follow-up of a single center.

Materials: The study was approved by the Ethics Committee of Aragon. The most frequent cause were surgical complications of the biliary branches and bile duct and in 100% of cases the ELLA DV Biliary prosthesis was implanted with a custom built in polydioxanone of different sizes and lengths according to each case. Stent patency, clinical symptoms, relevant laboratory data and complications during follow-up were analyzed.

Results: The clinical success was 100% and in only 1 case the stent migrated distally and could be replaced using an angioplasty balloon. The mean stent patency was of 84.55 months (60.29 - 108.80 months 95% CI). The GGT, bilirubin and alkaline phosphatase decreased in 33.41%, 59.26%, and 16.01% respectively. Of immediate complications the most important was hemobilia (6.5%) which didn’t require complementary measures. There 9 cases with restenosis or obstruction which required new drainage and/or surgical intervention.

Conclusions: The implantation of the ELLA absorbable stent is feasible and a safe and effective treatment for benign biliary strictures refractory to standard treatments.

Scientific Session 18
Ablation: Liver 1

Monday, March 19, 2018
3:00 PM–4:30 PM
Room: 407

Microwave ablation of primary and secondary liver malignancies: patient-specific predictors of success
H. Kapoor1, R. Jayavarapu1, Q. Han2, D. Raissi2
1University of Kentucky, Lexington, KY; 2University of Kentucky, Lexington, KY

Purpose: There is increasing evidence supporting the use of microwave ablation (MWA) for primary and secondary hepatic malignancies both as curative therapy and as a bridge to transplantation. However, early recurrence and residual tumor remain of concern. Likelihood of MWA success may be multifactorial. We intend to review our single-center large MWA population to shed some light on potential prognostic factors. All procedures were performed using the same high power MWA single antenna system.

Materials: We retrospectively reviewed demographics, concomitant TACE, degree and etiology of cirrhosis, biochemical scores, imaging characteristics, multifocality, and technical data. Rate of residual disease and recurrences, complications and survival data was obtained. Potential risk factors for residual disease were analyzed using multivariate regression analysis with SAS software (SAS Institute Inc., Cary, NC, USA).

Results: 53 patients underwent 100 MWA procedures. Total of 100 lesions, 76 were HCC’s and 24 Metastasis. Mean lesion size was 16 mm ± 9 mm. 75% of these patients had multifocal disease targeted in the same session. 22% of lesions had a concomitant TACE performed either within same or contralateral lobe. Seventy ablations were performed in cirrhotic livers (HePC 29, NASH 33, Alcoholic 7 and PBC 1) of whom 42% were Child-Pugh B/C. Complete ablation was achieved in 83% of lesions. Evidence of new disease was found in 47% of patients; 80% in HCC patients (p<0.01) with 65% outside the treated hepatic segment at median f/u of 12 months. Age (p<0.01), BMI>35 (p<0.01), cirrhosis grade (p<0.01), NASH (p = 0.01) and subcapsular location

Purpose: To identify prognostic predictors of clinical success in pyogenic liver abscess patients treated with percutaneous catheter drainage and antibiotics. A prognostic nomogram was developed and internally validated using the concordance statistic (c-statistic).

Materials: The study was approved by the institutional ethics review boards at both participating centers. This retrospective review comprised PLA patients treated with PCD plus antibiotics in two hospitals. We defined clinical efficacy time (CET) as the time from PCD procedure to clinical success, which was determined by re-examination. Based on the CET, prognostic predictors were identified with univariate and multivariate analyses, and a prognostic nomogram was developed and internally validated using the concordance statistic (c-statistic).

Results: One hundred thirty patients (74 patients in Cohort A and 56 patients in Cohort B) with a median CET of 20.8 days were included. Abscess with biliary origin (ABO; P < 0.001), diabetes mellitus (DM; P = 0.021) and preinterventional septic shock (PSS; P < 0.001) were identified as prognostic predictors after univariate and multivariate analyses, with median CETs of 32.5, 30.3, and 46.2 days, respectively, which were significantly longer than those patients without (18.3, 19.2, and 20.2 days, respectively). The prognostic analyses demonstrated that the more predictors (ABO, DM, and PSS) a patient exhibited, the longer CET for the combination therapy. A prognostic nomogram was developed and showed high accuracy, with a c-statistic of 0.66.

Conclusions: ABO, DM and PSS were prognostic predictors for the clinical prognosis of PLA patients treated with PCD plus antibiotics.
(p = 0.03) were significant predictors of residual disease. However, lesion’s size, biochemical scoring, prior TACE, multifocality, tumor pathology, segmental location and nearby vasculature did not have an impact.

**Conclusions:** Subcapsular location, degree of cirrhosis, presence of NASH, age and elevated BMI were independent factors associated with higher likelihood of residual disease. This high rate of recurrence after MWA in the HCC subset, warrants further investigation into factors predicting early recurrence and potential adjuvant therapies.

### 3:09 PM Abstract No. 172

**The McALBI score: a simplified predictive model for postprocedure hepatic dysfunction following microwave ablation of hepatocellular carcinoma in cirrhotic patients**

J. McWilliams1, B. Dubin1, A. Yuen1, E. Lee1, H. Trieu2, S. Raman2, D. Lu1; 1David Geffen School of Medicine at UCLA, Los Angeles, CA; 2David Geffen School of Medicine at UCLA, Los Angeles, CA

**Purpose:** To determine the risk factors and create a simplified predictive model for postprocedure hepatic dysfunction following microwave ablation (MWA) of hepatocellular carcinoma (HCC) in cirrhotic patients.

**Materials:** An IRB-approved retrospective review of all MWA procedures for HCC in cirrhotic patients at a single academic institution between May 2011 and September 2015 was performed. Preprocedure demographic and laboratory data was collected, as well as intraprocedure data regarding extent of ablation performed. Clinical and laboratory review was undertaken to detect the development of postprocedure hepatic dysfunction or liver failure in the 90 days following MWA. Postprocedure hepatic dysfunction was defined as any one of the following: increase in Child-Pugh score by 2 or more; increase in total bilirubin by 2 or more; or new ascites or encephalopathy. Postprocedure liver failure was defined as all three of the following: increase in bilirubin to 5 or greater; increase in international normalized ratio (INR) to 1.5 or greater; and development of ascites or encephalopathy. Multiple regression analysis was performed based on preprocedure and intraprocedure parameters to create a predictive model for development of hepatic dysfunction.

**Results:** 291 MWA procedures in 243 patients had complete preprocedure, intraprocedure, and postprocedure data. 37 procedures (12.7%) resulted in postprocedure hepatic dysfunction, which was often transient, and 4 procedures (1.4%) resulted in liver failure. Multiple regression analysis showed that a simple predictive tool, obtained by subtracting the total bilirubin from the albumin (McALBI score), accurately predicted the presence or absence of postprocedure hepatic dysfunction. Hepatic dysfunction occurred in 36/180 (20%) procedures with a McALBI score of 3 or lower, but in only 1/110 (0.9%) procedures with a McALBI score greater than 3.

**Conclusions:** Postprocedure hepatic dysfunction occurs in 12.7% of cirrhotic patients following MWA for HCC, and can be predicted using a novel and simple measurement of albumin minus total bilirubin (McALBI score). Hepatic dysfunction is extremely unlikely in the setting of a McALBI score greater than 3.

### 3:18 PM Abstract No. 173

**Microwave ablation for hepatocellular carcinoma: single-center 4-year experience with long-term follow-up**

J. Lopera3, G. Kroma2, A. Garza-Berlanga3, J. Walker4, R. Sun1; 1UT Health Science Center in San Antonio, San Antonio, TX; 2University of Texas Health Science Ctr, San Antonio, TX; 3N/A, San Antonio, TX; 4UTHSCSA, San Antonio, TX; 5University of Texas Health Sciences Center San Antonio, San Antonio, TX

**Purpose:** To report our 4-year experience with treatment of HCC with the use of microwave ablation (MWA) in patients with over 1 year of clinical and imaging follow-up.

**Materials:** A retrospective review of patients that underwent MWA for the treatment of early HCC in the last 4 years was performed in a single institution. Only patients with over 1 year of clinical and imaging follow-up were included. Patients with prior ablations or TACE; and patients that received combined ablation and TACE were excluded. MWA ablations were performed with a single probe using the Acculis system. Pathology results of the explants were reviewed in patients that received liver transplantation after the ablation. Axial contrast-enhanced images (CT/MRI) were obtained at 3, 6, and 12 m after the ablations and every 6 months after if complete response was obtained. Nodular or irregular enhancement in the ablated area was diagnosed as residual/recurrent disease.

**Results:** MWA was performed in 69 lesions in 46 patients with HCC (M = 31, F = 15, ages 73-42 mean 59 y). Mean lesion size was 2 cm (range, 0.6-4.5 cm). Major complications in 10% of patients included: bleeding requiring embolization (n = 3), perihepatic hematoma requiring observation (n = 1) and pain and ileus (n = 1). Residual/recurrent disease was seen in follow-up imaging in 42% of the treated lesions: in 14 at 3, 7 at 6 and in 8 lesions at 12 months of follow-up respectively. No correlation was seen between tumor size and treatment failure. Reablations were performed in 9 and TACE in 13 patients for residual disease. Mean follow-up was 27 months (range, 12-75), 8 patients died. Thirteen patients had OLT at mean 12 of months after ablations (range, 3-38 m). Pathology of the 13 explants showed viable tumors in 40% (8/20) of treated tumors.

**Conclusions:** Long-term follow-up of patients with HCC treated with MWA show a relatively large incidence of residual and recurrent tumors in the treated area. Better tumor targeting and/or larger ablations are needed to obtain improved local tumor control.

### 3:27 PM Abstract No. 174

**A retrospective comparison of ablation volumes, clinical response, and outcomes of overlapping versus simultaneous microwave ablation in patients with hepatocellular carcinoma**

E. Pang1, R. Bant1, J. Guynan1, S. Gadani1, J. Kao1, L. Morel-Ovalle1, K. Pereira1, K. Vaheesan1, A. Fang1; 1Saint LOUIS UIS University, St. Louis, MO

**Purpose:** To compare the ablation volumes, clinical response, and outcomes after microwave ablation (MVA) with overlapping
ablations (OA) vs. simultaneous ablations (SA) in patients with hepatocellular carcinoma (HCC).

**Materials:** This retrospective study included 45 patients with 45 HCC who underwent MWA between 2013 and 2017. MVA was performed sequentially with one antenna in the OA group (n = 33; 23 M, 10 F; mean age: 61.9 ± 9) and simultaneously with two antennae in the SA group (n = 12; 10 M, 2 F; mean age: 62.2 ± 8.7). Patients were followed with CT or MR imaging for at least a year to identify tumor progression. Clinical and technical factors were reviewed. Ablation length, diameter, and volumes on first follow-up cross-sectional imaging were calculated. Tumor response, including complete response (CR), partial response (PR), stable disease (SD), and progressive disease (PD) were evaluated according to mRECIST. Local tumor progression (LTP), time to progression (TTP), progression-free survival (PFS), and overall survival (OS) were compared between groups.

**Results:** There were no significant differences between both groups in terms of tumor etiology, MELD, ECOG, Child-Pugh, BCLC scores, and median tumor size (OA: 2.45 cm; SA: 3 cm). The median wattage for OA and SA groups was not significantly different (66.8 W ± 16.7 vs. 58.3 W ± 11.6). Mean ablation time was longer in the OA group compared to the SA group (16.1 min ± 4.8 vs. 9.1 min ± 2.0, p<0.0001). Mean ablation volumes were larger in the SA group compared to the OA group (62.7 cm³ ± 20.9 vs. 36.2 cm³ ± 39.7, p<0.0001). There were no significant differences between OA and SA groups in terms of CR, PR, SD, or PD on follow-up imaging, as well as clinical outcomes, including LTP (median: 5 vs. 6.5 mo), TTP (median: 5 vs. 4 mo), and PFS (median: 13 vs. 17 mo). Overall survival was similar between groups at 12 mo (90.9% vs. 91.7%), but showed a decreased trend for the OA group at 24 mo (50% vs. 88.9%).

**Conclusions:** SA leads to larger ablation volumes and shorter ablation times in patients with HCC but is not associated with improved clinical response, LTP, TTP, PFS, or OS when compared to patients undergoing OA.

**3:36 PM Abstract No. 175**

**Comparison of safety and efficacy of microwave ablation vs. radiofrequency ablation for hepatocellular carcinoma**

E. Wehrenberg-Klee1, R. Arellano1, R. Uppot1, O. Zurkiya1, P. Mueller1, A. Zhu1, P. Vagefi1, S. Ganguli2; 1Massachusetts General Hospital, Boston, MA; 2Massachusetts General Hospital/Harvard Medical School, Boston, MA

**Purpose:** Radiofrequency ablation (RFA) is a well-established loco-regional therapy for hepatocellular carcinoma (HCC) with long-term outcome data. Microwave ablation (MWA) for HCC is a more recently adopted percutaneous thermal ablative therapy, which currently lacks data comparable to RFA. This study compares outcomes of RFA and MWA for HCC in a standardized patient population – those patients with HCC being bridged to liver transplant.

**Materials:** This IRB-approved, HIPPA-compliant study retrospectively reviewed the medical records of all patients between 2005 and 2015 listed for liver transplant with HCC exception points (within Milan criteria) at a single tertiary-care institution. Patients with HCC who received either MWA or RFA as initial bridging therapy and for whom pre-ablation and post-ablation clinical follow-up were available were included in the study. Baseline characteristics, presence of residual or recurrent disease after treatment, need for repeat procedures and successful liver transplantation were collected for statistical analysis. Adverse events were assessed by CTCAE 4.0 criteria.

**Results:** 136 patients were included in the study (46 MWA, 90 RFA). At time of treatment there were no significant differences in patient group characteristics, including tumor burden or underlying liver disease. 85% of patients who received MWA received a transplant, whereas 74% of RFA patients made it to transplant. After MWA, 11 patients required further loco-regional therapy prior to transplant, 7 of these for residual disease (15%). Following RFA, 24 patients required further therapy, 17 of these for residual disease (19%). 31 MWA patients reported grade 1-3 adverse events (67%), and 57 RFA patients reported grade 1-3 adverse events (63%). Pain was the most common adverse event for both treatments.

**Conclusions:** MWA is comparable to RFA as far as safety and efficacy, and can successfully bridge HCC patients to transplant with similar rates of adverse events and need for reintervention.

**3:45 PM Abstract No. 176**

**Effect of microwave ablation on iodized oil stain after chemoembolization of hepatocellular carcinoma**

N. Voutsinas1, M. Kolber2, V. Bishay3, M. Ranade4, R. Patel5, F. Nowakowski6, S. Lewis7, R. Lookstein8, A. Fischman6, E. Kim4; 1Icahn School of Medicine at Mount Sinai Medical Center, New York, NY; 2Mount Sinai Beth Israel, New York, NY; 3Icahn School of Medicine at Mount Sinai Hospital, New York, NY; 4Icahn School of Medicine at Mount Sinai Hospital, New York, NY; 5Mount Sinai Hospital, New York, NY; 6Mount Sinai Medical Center, New York, NY; 7Icahn School of Medicine at Mount Sinai, New York, NY

**Purpose:** Conventional transarterial chemoembolization with lipiodol stain (cTACE) in combination with microwave ablation (MWA) has potential for synergistic effects in treating hepatocellular carcinoma (HCC). Lipiodol stain can be used as a target for CT guidance and frequently changes size post-MWA. We evaluated HCC lesions treated with combination cTACE/MWA for change in stain size as a predictor of response and local recurrence.

**Materials:** This study is an IRB-approved retrospective analysis of 58 patients (40 male, mean age 67.1) who underwent combination cTACE/MWA between 1/2011-1/2014 that demonstrated discernible lipiodol staining on initial and follow-up examinations. Axial diameter of tumor stain was recorded pre- and post-MWA and at 2 month follow-up. Relative changes in diameter were stratified and correlated with time to local recurrence, history of prior treatment, initial tumor size, and presence of a nearby vessel (heat sink). Adverse events (AEs) were recorded. Radiographic response was assessed by mRECIST.

**Results:** Relative to pre-ablation staining, post-MWA CT demonstrated median decrease in lesion size of 10.7% (-9.5% to 30%), and initial follow-up imaging demonstrated median size decrease of 22.9% (-9.4% to 42.1%). There were no AEs at 30 days. Complete response was 90.7% at 90 days, with a local recurrence rate of 28.8% at maximum follow-up. Median tumor
diameter decrease was greater in patients without local tumor recurrence at 6 months (23 vs 21.4%) and 12 months (23.1 vs 19.8%), and in tumors less than 2 cm vs tumors greater than 2 cm (23.5 vs 20.3%), but these differences did not reach statistical significance. A history of prior locoregional therapy (p<0.02) and lesions near heat sink vessels (p<0.01) were predictive for local recurrence.

Conclusions: Changes in size of lipiodol stain following combination cTACE/MWA did not correlate to complete response or risk of local recurrence. Patients with prior locoregional therapy and lesions near heat sinks had significantly higher local recurrence rates.

3:54 PM  

Abstract No. 177

Irreversible electroporation for unresectable hepatocellular carcinoma: initial experience
N. Kalra1, P. Gupta1, H. Bhujade1, U. Gorsii1, Y. Chawla1, N. Khandelwal1; 1Postgraduate Institute of Medical Education and Research, Chandigarh, Union Territory

Purpose: To evaluate the efficacy and safety of irreversible electroporation (IRE) in the treatment of unresectable hepatocellular carcinoma (HCC) in patients in whom radiofrequency ablation (RFA) cannot be done due to difficult tumor location.

Materials: This was a retrospective analysis of patients with unresectable HCC who had been treated with IRE from September 2014 to June 2017. The study was approved by the local review board. A total of 21 HCCs in 21 patients with cirrhosis were treated with IRE. The choice of IRE was based on the tumor location that precluded radiofrequency ablation. There were 7 subcapsular or exophytic tumors, 11 perivascular tumors and 3 peribiliary tumors. 16 patients had Child-Pugh class A disease and 5 patients had Child-Pugh class B disease. Median age and median tumor size were 64 years (range, 40-84 years) and 26 mm (range, 14-40 mm) respectively. Treatment response was evaluated on multiphase computed tomography scans performed at 4 weeks following the procedure and then every 3 months. Complications, median follow-up, local tumor progression and median local tumor progression-free survival (PFS) were recorded. Complications were graded according to the Society of Interventional Radiology classification.

Results: Technical success was achieved in all the patients. Median follow-up was 10 months (range, 2-30 months). Local tumor progression was seen in 5 (24%) patients. Median local tumor PFS was 7 months (range, 3-30 months). Tumor size less than 2.5 cm had a significant association with local tumor PFS (p = 0.045). Other parameters including etiology of cirrhosis, tumor location, segmental portal vein thrombosis and baseline alpha-fetoprotein level did not affect local tumor PFS. Complications were seen in 9 patients and were classified as grade I and II in 7 patients. No procedure related mortality was seen.

Conclusions: IRE is an effective and safe procedure for ablation of HCC at locations where RFA is difficult or contraindicated. Prospective studies with larger number of patients are required to validate the results of this study.

4:03 PM  

Abstract No. 178

Tumor size and geometry in patients treated with radiofrequency ablation plus lyso thermosensitive liposomal doxorubicin (LTLD)
H. Celik1, P. Wakim1, J. Karanian1, W. Pritchard1, M. Castro1, S. Leonard1, N. Borys2, M. Dewhirst3, R. Lencioni4, B. Wood1; 1National Institutes of Health, Bethesda, MD; 2Celsion Corporation, Princeton, NJ; 3Duke University, Durham, NC; 4University of Miami, Miami, FL

Purpose: Lyso-thermoselective liposomal doxorubicin (LTLD) releases cytotoxic doxorubicin locally in the region of mild hyperthermia (40–42 °C). LTLD had been shown to be effective drug delivery method for hepatocellular carcinoma in animal models mouse tumor models compared with conventional free drug or non-thermally sensitive liposome therapies. A recent phase III clinical trial (HEAT) compared survival of (a) radiofrequency ablation (RFA)-only and (b) LTLD administration together with RFA treatment patients (RFA+LTLD) but did not meet defined endpoints. This post hoc sub-analysis aims to provide ranges of tumor properties, where RFA+LTLD patient survival is better than RFA-only patient survival using Cox proportional hazard model.

Materials: HEAT study is a double-blind and randomized controlled phase III trial of RFA-only vs. RFA+LTLD in patients with 3-7 cm diameter hepatocellular carcinoma (HCC). Although the trial included single as well as multiple tumor patients, we evaluated only patients with single tumors to normalize and simplify the study group and hypotheses (RFA only n = 210 vs. RFA+LTLD n = 227 patients). Tumor volume, longest diameter, area, ellipticity, one-month post ablation lesion volume, burn time, and burn time per tumor volume were investigated to find useful ranges for RFA+LTLD patients.

Results: We found the ranges of different geometrical sizes, where LTLD was significantly different (useful) to the patients compared with RFA-only group (Table).

Conclusions: LTLD may improve overall survival as RFA duration per unit tumor volume increases. This is a post hoc study in search of favorable ranges, therefore the results are not definitive and need to be confirmed with further studies. Finally, for any drug-device combination studies, investigators need to consider the drug-device interactions and novel methodologies for response criteria to define potential benefits and standardize and optimize the combination treatments.

<table>
<thead>
<tr>
<th>Tumor Size vs. Statistics</th>
<th>Min-Max</th>
<th>Useful Range</th>
<th>P Value</th>
<th>Hazard Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (mm)</td>
<td>20-85</td>
<td>39.5-52</td>
<td>0.041</td>
<td>1.72</td>
</tr>
<tr>
<td>Volume (ml)</td>
<td>5.2-246.8</td>
<td>30-105.5</td>
<td>0.044</td>
<td>1.651</td>
</tr>
<tr>
<td>Area (cm²)</td>
<td>2.75-42.73</td>
<td>10.3-16.5</td>
<td>0.036</td>
<td>1.738</td>
</tr>
<tr>
<td>Ellipticity (a.u.)</td>
<td>0-0.83</td>
<td>0.475-0.73</td>
<td>0.041</td>
<td>1.54</td>
</tr>
</tbody>
</table>
Percutaneous Emprint™ microwave ablation of malignant liver tumours: a report of the first 100 cases
U. Pua1, G. Chan2; 1Tan Tock Seng Hospital, Singapore, Singapore; 2MOHH, Singapore, AK

Purpose: A new MWA device, the Emprint™ Microwave Ablation System, is purported to achieve spherical and predictable ablation zones. We aim to evaluate the clinical efficacy and short-term safety profile this device in the percutaneous ablation of malignant liver tumors.

Materials: This is a retrospective IRB-approved study of patients who underwent percutaneous MWA with the Emprint™ device from Jan 2015 to April 2017 in our institution. Patient demographics, technical success rates, as well as 30-day mortality and morbidity were examined. The presence of residual disease or recurrence was recorded after review of contrast-enhanced CT/MRI up to 24 months post procedure.

Results: A total of 119 ablations were performed in 102 patients, with a mean tumor diameter of 1.7 (1.0 – 5.6) cm. Technical success rate was 99.2%. Residual disease rate at 6 weeks was 6.2%, while a recurrence rate of 2.7% was recorded. There was no procedural related mortality. One major complication of hemorrhage requiring angioembolization was recorded (0.8%), while minor complication rate was 17.6% (pneumothorax n = 5, small subcapsular haematoma/haemoperitoneum n = 5, over sedation n = 5, pleural effusion n = 4, transfusion reaction to platelets n = 1, bacteremia n = 1, focal portal vein thrombosis n = 1).

Conclusions: Our study suggests that the Emprint™ MWA device is a safe device that allows a high degree of technical success with a low rate of residual disease and short-term recurrence.

Primary technique efficacy, local tumor progression, patient survival, and complications following outpatient percutaneous image-guided thermal ablation of primary intrahepatic cholangiocarcinoma
M. Connolly1, J. Kachura2; 1University of Toronto, Toronto, ON; 2Toronto General Hospital, Toronto, ON

Purpose: The purpose of this study was to determine primary technique efficacy (TE), time to local tumor progression (TTLP), patient survival and complications following outpatient percutaneous image-guided thermal ablation as the initial treatment for primary intrahepatic cholangiocarcinoma (ICC).

Materials: Ethics board approved, single arm, retrospective, cohort study of patients with pathologically proven primary ICC treated with percutaneous thermal ablation as the initial therapy at a tertiary referral center from 1999 to 2017. Primary TE, defined as no tumor enhancement on the first post-thermal ablation follow-up imaging, was determined. Local tumor progression was defined as abnormal liver enhancement with nodularity or mass effect adjacent to an ablation zone on a follow-up CT or MRI. Complications were graded as per SIR guidelines. Factors affecting primary TE, TTLP, and complication rates were analyzed.

Results: The patient cohort consisted of 6 females and 10 males. Mean patient age was 65 years (range, 47-81). All 16 patients had chronic liver disease (hepatitis B: 6 patients, hepatitis C: 4, alcohol related cirrhosis: 3, NASH: 2, and hemochromatosis: 1). All 16 patients were Child-Pugh class A. Mean tumor diameter was 26 mm (range, 12-44). 12 patients were diagnosed with biopsy performed at the time of ablation, whereas 4 were diagnosed with biopsy prior to consultation for thermal ablation. 13 patients were treated with radiofrequency ablation and 3 patients treated with microwave ablation. Primary TE was 81%. No major complications occurred. Mean follow-up was 32 months (range, 4-135). In patients with primary effectively ablated tumors, 3, 14 and 25-month local tumor progression-free survival were 91.7 ± 8.0% [± SE], 81.5 ± 11.9% and 48.9 ± 19.2%. Overall, cumulative 1, 2 and 3-year patient survival was 73.3% (11/15), 53.8% (7/13) and 41.7% (5/12), there was 1 patient lost to follow-up at 4 months post procedure. Tumor size was associated with both reduced primary TE and shorter TTLP (p<0.05).

Conclusions: Thermal ablation is a safe and effective treatment for small primary intrahepatic cholangiocarcinoma.

Machine learning and machine vision image analysis can predict treatment response from preprocedural imaging alone for Y90 radioembolization and DEB-TACE in hepatocellular carcinoma
S. Arndt1, T. Sadow2, J. Milburn1, T. Nguyen1, D. Goldman9, J. Gimenez1, V. Ramalingam1; 1Ochsner Clinic Foundation, New Orleans, LA; 2Medstar Georgetown University Hospital, New Orleans, LA; 3University of Queensland - Ochsner Clinical School, New Orleans, LA

Purpose: To evaluate machine learning and machine vision image texture analysis for preprocedural evaluation of dichotimized mRECIST treatment response in drug-eluting bead transarterial chemoembolization (DEB TACE) and radioembolization treated hepatocellular carcinoma (HCC) patients.

Materials: HCC tumors in 40 patients treated with DEB-TACE with available preprocedural imaging and 1 month follow-up were identified in a retrospective review. Arterial phase preprocedural CT was evaluated and the axial image with the greatest enhancing tumor diameter was chosen. Images were manually segmented and image analysis was performed with KNIME image processing...
software. A total of 102 rotation invariant image features were extracted, loosely grouped into haralick, tamura, and pixel intensity histogram based features. Independent component analysis was used for dimensionality reduction. Internal validation was performed via 250 repetition sampling with repletion (bootstrap) to evaluate a regularized logistic regression. Similar analysis was performed for 30 patients with HCC tumor that were treated with radioembolization. Support vector machines were also used for analysis of both groups and compared to logistic regression.

**Results:** Machine learning radiomic image analysis preprocedural categorization of response for DEB-TACE showed AUC 0.600 ± 0.14, with p < 0.0001 for a similar result by chance. Specificity 71 ± 14% and negative predictive value of 80 ± 10% and sensitivity 38 ± 27% and positive predictive of 25 ± 18% were noted. Support vector machine models provided a significant improvement with AUC 0.720 ± 0.199, with p < 0.0001 for comparison to logistic regression. For radioembolization patients AUC was 0.626 ± 0.17, with p < 0.0001 for a similar result by chance. Specificity 65 ± 20% and Negative predictive value 68% and Sensitivity 61 ± 24% and positive predictive value 58% were noted. Support vector machine models provided a significant improvement with AUC 0.858 ± 0.114, and p < 0.0001 for comparison to logistic regression.

**Conclusions:** From preprocedural imaging alone, classification of DEB TACE and radioembolization treatment response to can be accomplished with image texture analysis.

**3:09 PM Abstract No. 182**

**Comparison of cone-beam CT versus computed tomography intraarterial angiography for intra procedural TACE planning**

E. Lin¹, A. Jones², G. Chintalapani³, J. Ensor⁴, B. Odisio⁵; ¹The University of Texas MD Anderson Cancer Center, Sugar Land, TX; ²MD Anderson Cancer Center, Houston, TX; ³Siemens Medical Solutions USA, Inc., Hoffman Estates, IL; ⁴Houston Methodist, Houston, TX; ⁵UT MD Anderson Cancer Center, Houston, TX

**Purpose:** To compare imaging characteristics of intraarterial cone-beam computed tomography angiography (CBCTA) versus computed tomography angiography (IACTA) for transarterial chemoembolization (TACE) planning.

**Materials:** This single-institution retrospective study included 144 patients submitted to 181 TACE sessions under conscious sedation (CBCTA, n = 111; IACTA, n = 70) from January 2015 to July 2017. CBCTA was performed using a single plane angiography system equipped with a 30 × 40 cm flat detector (Syngo 6s DR DynaCT, Artis Zee, Siemens, Germany). IACTA was performed using a hybrid Angio-CT system equipped with a 128-slice sliding gantry CT (MIYABI Angio CT, Siemens, Germany). Similar intraarterial contrast injection protocols were utilized for both modalities. Multi-planar reformatted CBCTA and IACTA images (5-10 mm MPR MIP Thick) were independently reviewed by two readers in a dedicated workstation and classified using a binary (yes vs no) system (breathing motion artifact, and field of view [FOV] coverage of entire liver) or a 3/4-level ordinal grading system (tumor conspicuity, tumor arterial feeder conspicuity, streaking artifacts, overall vessels conspicuity, and overall image quality). CBCTA and IACTA groups were compared using a F-test and score test.

**Results:** There were no significant differences in patient demographic andumor characteristics between the IACTA and CBCTA groups. IACTA was significantly superior to CBCTA in respect to better tumor conspicuity (P < 0.01), tumor arterial feeder conspicuity (P = 0.02), less frequent incidence of streaking artifact (P < 0.01), FOV coverage of entire liver (CBCTA: 22%; IACTA: 84%; P < 0.01), overall vessel conspicuity (P < 0.05), and overall image quality (P < 0.001). CBCTA tended to have more frequent image degradation due to breathing motion during acquisition (CBCTA: 10%; IACTA: 1.4%; P = 0.057).

**Conclusions:** IACTA provides more reliable and consistent imaging information when compared to CBCTA for liver soft-tissue and vessel analysis for intra procedural TACE planning. Further studies are required to explore the diagnostic utility and radiation dose of IACTA in the context of TACE planning in a hybrid CT angio suite.
may have a key role in identifying certain lower LI-RADS classification lesions that may benefit from aggressive treatment. This study shows that the development of a pseudocapsule and portal venous washout are the main imaging findings associated with progression in LI-RADS classification and thus may represent more aggressive tumor phenotypes. Interventionalists may be able to target these lesions at an earlier LI-RADS stage in order to achieve improved outcomes.

3:27 PM Abstract No. 184

Using FDG PET/CT to predict response to IRE in nonresectable pancreatic cancer: a retrospective analysis of 50 patients
A. Amin¹, V. Sinha², T. Sullivan⁴, N. Mehta³, M. Doshi⁵, R. Kuker¹, R. Lencioni³, G. Narayanan⁴; ¹University of Miami Miller School of Medicine, Miami, FL; ²University of Miami, Miami, FL; ³N/A, Miami, FL; ⁴University of Miami-Miller School of Medicine, Miramar, FL

Purpose: To assess the ability of FDG PET/CT to predict outcome following irreversible electroporation (IRE) in patients with unresectable pancreatic adenocarcinoma.

Materials: This retrospective study included 47 patients (25 women, 22 men; age range, 42-83; median age, 67) with unresectable pancreatic adenocarcinoma who underwent a total of 50 computed tomography-guided percutaneous IRE (Nanoknife, Angiodynamics, Latham, NY) between May 2012 and August 2017. The median tumor size was 3.2 cm (range, 1-7.2 cm); 17% were known to have undergone pre-IRE RT, 67% were stage III (Locally advanced), and 33% had metastatic disease at treatment. FDG PET/CT was performed within 24 hours of treatment for each patient to obtain functional imaging prior to inflammatory response. SUV max of pretreatment imaging was compared to 24 hr FDG PET/CT.

Results: Technical success of IRE was 100%. Patients with an immediate postoperative SUV max of < 4.2 experienced greater OS (P < 0.003) (A, table). Pretreatment SUV max < 4.2 did not predict a greater OS (P = .543) (B, table).

Conclusions: FDG PET/CT is an effective tool for predicting outcome of IRE treatment. SUV max of < 4.2 on FDG PET/CT performed within 24 hours of pancreatic IRE was found to be associated with higher overall survival.

<table>
<thead>
<tr>
<th>PET/CT 24 hours post IRE</th>
<th>SUV Max</th>
<th>Median Survival</th>
<th>Lower Upper</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4.2</td>
<td>9.9</td>
<td>5.8</td>
<td>15.1</td>
<td>.003*</td>
</tr>
<tr>
<td>&gt; 4.2</td>
<td>6.97</td>
<td>3.63</td>
<td>7.87</td>
<td></td>
</tr>
<tr>
<td>PET/CT before IRE</td>
<td>&lt; 4.2</td>
<td>9.40</td>
<td>3.47</td>
<td>16.5</td>
</tr>
<tr>
<td>&gt; 4.2</td>
<td>7.03</td>
<td>4.30</td>
<td>14.3</td>
<td></td>
</tr>
</tbody>
</table>

SUV max and survival of patients who underwent PET/CT at 24 hours compared with patients who underwent PET/CT before IRE. *P values reflect median survival.

Table 1.

Pathological Tumor Necrosis

<table>
<thead>
<tr>
<th>Radiologic response</th>
<th>CT (n = 33)</th>
<th>MRI (n = 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PR</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>CR</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

Accuracy of computed tomography versus magnetic resonance imaging for detection of tumor necrosis after transarterial chemoembolization for hepatocellular carcinoma
E. Fayazzadeh¹, G. McLennan¹; ¹Cleveland Clinic, Cleveland, OH

Purpose: To compare accuracy of CT and MRI modalities to detect complete tumor necrosis following TACE in patients with hepatocellular carcinoma (HCC) undergoing liver transplantation.

Materials: 51 patients with HCC receiving drug-eluting bead (DEB)-TACE before liver transplantation were retrospectively studied based on the latest available multiphasic contrast imaging modality (July 2010–March 2017) used to assess index tumor response to therapy according to modified RECIST criteria (CT, 33 patients; MRI, 18 patients). Results were classified as complete response (CR), partial response (PR), and stable disease (SD) which were then correlated with the corresponding extent of actual tumor necrosis at the time of pathological examination of liver explants after transplantation (0-29%, 30%-99%, and 100%). The average durations from imaging to pathology were 48.73 ± 40.55 and 40.06 ± 26.60 for patients evaluated by CT and MRI, respectively (P = 0.43). Diagnostic sensitivity, specificity, and positive/negative predictive values of the imaging modalities were calculated based on the presence or absence of complete (100%) necrosis on pathological examination. Fisher’s exact test was used for categorical data analysis.

Results: Tumor response to treatment in CT and MRI images were completely consistent with degree of pathological tumor necrosis in 52% and 56% of cases, respectively. Radiological complete response was not shown as a strong predictor of pathological tumor necrosis using CT (P = 0.07) or MRI (P = 0.33) modalities. For detection of complete tumor necrosis, CT had a sensitivity, specificity, positive predictive value, and negative value of 77%, 60%, 56%, and 80%, respectively. For MRI, these figures were 57%, 73%, 57%, and 73%, respectively.

Conclusions: In this study with a very limited sample size, CT had a higher sensitivity but lower specificity than MRI in detection of complete HCC necrosis. The low positive predictive values in both modalities necessitates interpretation of outcomes as complete response with extreme caution.
CEUS and MRI appearance of local recurrent/residual hepatocellular carcinoma post-radiofrequency ablation

E. Nzekwu1, K. Kunimoto2, V. Kotha3, J. Wong4; 1University of Calgary, Calgary, AB; 2Cumming School of Medicine University of Calgary, Calgary, Alberta; 3Foothills Medical Centre, Calgary, AB; 4N/A, Calgary, AB

Purpose: To describe the correlation of CEUS and MR imaging appearances of local recurrent/residual HCC post-radiofrequency ablation (RFA).

Materials: A single-center retrospective review of all the hepatic radiofrequency ablations (RFA) for HCC between January 2011 to January 2016 was conducted. 275 RFAs were performed on 227 patients with 116 recurrent/residual lesions detected in 91 patients. 59/91 patients had CEUS and MRI performed. Of these, 26 patients with extrazonal recurrence were excluded from the analysis. Residual disease was defined as lesions detected within 90 days of RFA, lesions detected after 90 days were classified recurrent. CEUS and MR imaging and reports were reviewed, and the location, morphology and enhancement characteristics of the tumors were noted. Typical appearance of HCC was defined as early arterial enhancement with portal venous washout, all other findings deemed atypical. Atypical features included an array of enhancement profiles ranging from delayed or subtle arterial enhancement to delayed or absent portal venous washout.

Results: 34 lesions in 30 patients (25 males, mean age 64 years) met criteria for local recurrent/residual tumors at an RFA site, 20 (62%) were classified as recurrent lesions with a mean time to detection of 583 (203-2930) days. Hepatitis C (n = 15, 50%) was the commonest underlying hepatic disease. 32 (94%) lesions were identified by MRI and 30 (88%) lesions were detected on CEUS. All lesions not detected on CEUS were localized to segment V and VII of the liver on MRI. Typical appearances were seen in 19 (56%) of CEUS and 23 (68%) of MRI studies. Atypical morphology was seen in 11 (32%) of CEUS and 9 (26%) of MRI studies. The enhancement characteristics were discordant between CEUS and MRI in 17% of cases.

Conclusions: Atypical imaging appearances of recurrent HCC post-RFA were common on both MRI and CEUS and were discordant in a large proportion of this small cohort. Our findings suggest that CEUS and MRI complement one another for detection of these lesions and could be used in alternate sequential fashion for surveillance.

Renal cell carcinoma local recurrence vs. non-malignant imaging mimics post-radiofrequency ablation: incidence, imaging features, and natural history

D. Cool1, J. Kachura2; 1University of Western Ontario, London, ON; 2Toronto General Hospital, Toronto, ON

Purpose: To compare the frequency, imaging characteristics and natural history of non-malignant imaging mimics of tumor recurrence following successful radiofrequency ablation (RFA) of RCC with confirmed local recurrence.

Materials: A single-center, retrospective case-control study evaluated all patients with successful RFA treatment of biopsy-confirmed RCC or suspicious oncotic neoplasm between April 2004 and June 2016. Inclusion criteria included minimum post-RFA follow-up of 10 months and at least 2 contrast-enhanced studies post-RFA. 256 patients and 268 tumors were included (mean follow-up 4.2 ± 2.6 years). All RFA procedures were performed under conscious sedation using a multi-tined RF electrode. Post-RFA imaging follow-up was with either multiphase CT, MRI or contrast-enhanced US. All patients flagged by the radiologist as suspicious for local recurrence were analyzed and stratified into 1) Local recurrence (LR) or 2) Non-malignant changes (NMC). Patients were categorized as NMC only if a biopsy confirmed no viable tumor or if the abnormal features resolved on follow-up imaging.

Results: Local recurrence and non-malignant changes occurred in 3.4% (9/268) and 2.6% (7/268) of all treated tumors. Mean age at time of RFA (LR 64.7 ± 14.1, NMC 69.9 ± 8.5 years), tumor size (LR 2.9 ± 0.8, NMC 2.4 ± 0.4 cm), and time post-RFA to imaging abnormality detection (LR 29.0 ± 19.5, NMC 40.3 ± 17.7 months) were not significantly different between the groups. Respective tumor histologies were LR: clear cell 8 (89%); papillary 1 (11%) and NMC: clear cell 4 (57%); papillary, chromophobe & oncotic neoplasm 1 each (14%). Imaging characteristics differed between the two groups as the amount of CT enhancement above the precontrast baseline was significantly higher (p<0.001) for the LR group (155 ± 38 HU) than the NMC group (28 ± 8 HU). Post-ablation nodular enhancement either centrally within the region of coagulation or along the extra-renal ablation margin was more commonly associated with NMC (4/5 tumors), while nodular enhancement along the renal parenchyma margin was always LR (8/8 tumors).

Conclusions: Non-malignant changes post-RFA can mimic RCC recurrence on imaging and should be recognized to minimize unnecessary treatment.

Imaging predictors of radiologic response after bland transarterial embolization for hepatocellular carcinoma

Q. Wang1, J. Ronald2, P. Suhocki2, C. Kim2; 1Duke Univ/Huazhong University of Science and Technology, Durham, NC; 2Duke University Medical Center, Durham, NC

Purpose: Given the numerous locoregional treatment modalities available for the management of HCC, strategies are needed to determine the optimal therapy for a given patient. While predictors of response have been well studied for transarterial chemoembolization, they are poorly understood for transarterial embolization (TAE). Therefore, the purpose of this study was to identify whether there are predictors of radiologic response after TAE for HCC and whether imaging response correlates with survival.

Materials: Retrospective review of our procedural database revealed 208 patients (156 males, 52 females mean age 61) who
underwent first-time bland embolization for HCC and had 3-month imaging follow-up. The radiologic response at 3 months was categorized based on mRECIST criteria. Imaging features were ascertained from the preprocedural CT or MRI. Imaging predictors of radiologic response at 3 months was calculated with univariate and multivariate logistic regression analysis. The impact of radiologic response on survival was ascertained with the Kaplan-Meier technique and log rank test. A p-value less than 0.05 was considered statistically significant.

Results: Based on univariate analysis, predictors of a radiologic response (complete or partial response) at 3 months included presence of a capsule (p = 0.019), low number of lesions (0.002), and a lesion not at an interlobar location (0.011). Predictors of progressive disease at 3 months included a high AFP (0.002), larger tumor size (0.021), more tumors (0.001), and an interlobar location (0.001). On multivariate analysis, only the presence of a capsule predicted response (p = 0.002), whereas only a high AFP predicted progressive disease (p = 0.026). A positive radiologic response at 3 months correlated significantly with improved survival (45.3 versus 26.5 months). Progressive disease at 3 months correlated significantly with poorer survival (13.1 versus 40.1 months).

Conclusions: The presence of an HCC capsule and AFP levels were predictors of a positive and negative radiologic response at 3 months after TAE, respectively. The radiologic response at 3 months correlated significantly with survival.

4:12 PM Abstract No. 189
Is dual-phase C-arm CBCT accurate enough for the detection of colorectal cancer liver metastasis during liver intraarterial treatment? Results of a prospective study
O. Pellerin1, H. Peirrera1, G. Amouyal1, C. del giudicce2, C. Dén2, M. Sapoval1; 1Hôpital Européen Georges Pompidou, Paris, France

Purpose: This study aimed at calculated the Dual-Phase CBCT accuracy in the detection of colorectal cancer liver metastases (CRCCLM) compared to multi detector computed tomography (MDCT).

Materials: Between March 2012 and December 2015 49 consecutive patients referred to intraarterial treatment for CRCCLM were enrolled in a single-center prospective observational study approved by our institutional review board. All were examined with triphasique MDCT protocol and Dual-Phase CBCT before intraarterial treatment. Two blinded observers independently reviewed all examination. Dual-Phase CBCT diagnostic Sensibility (Se.) and Specificity (Sp.) were calculated using a 6-cell matrix method and using a “worse case scenario” defining a “real life” situation. Se. and Sp. of both phases were compared using McNemar’s test.

Results: The Dual-Phase CBCT early Arterial Phase (eAP) yielded a Se. of 93% and a Sp. of 85% and the late Arterial Phase (lAP) yielded a Se. of 99% of Sp. of 88% with the 6-cell matrix method. The probability to correctly diagnose a CRCCLM at the eAP and the lAP was 60% and 90% respectively. The worse case scenario yielded a Se. and a Sp. of 58% and 51% at eAP respectively (p<0.0001), and 84% and 70% at the lAP respectively and (p = 0.02)

Conclusions: The eAP had limited accuracy in the intra-procedural detection of CRCCLM. Only the lAP appears relevant and can be proposed to operators within the goal to correctly place the microcatheter allowing a correct intraarterial hepatic treatment.

4:21 PM Abstract No. 190
Quantitative 4D digital subtraction angiography: a novel technique for quantifying changes in hepatic arterial flow during transarterial embolization
C. Haran1, E. Meram1, G. Shaughnessy1, M. Wagner1, C. Mistretta1, P. Laeseke1; 1University of Wisconsin-Madison, Madison, WI

Purpose: Degree of stasis affects response to and survival after transarterial embolization (TAE). Despite this, angiographic endpoints during TAE are subjective and highly variable. Time-resolved 3D-Digital Subtraction Angiography (4D-DSA) is a recently developed technique that permits quantification of blood flow and velocity. We aimed to validate the accuracy of 4D-DSA for quantifying hepatic arterial blood flow/velocity along with its ability to show changes in flow during TAE.

Materials: Hepatic arteriography and TAE of two of the four liver lobes were performed in five female domestic swine using 100-300µm and 300-500µm Embosphere Microspheres. Conventional 2D- and 4D-DSAs were performed before, during, and after each embolization. From the 4D-DSA reconstructions, blood flow and velocity values were calculated for the common, right, left and lobar hepatic arteries using a pulsatility based algorithm. 4D-DSA flow and velocity values were compared to those measured using an intravascular Doppler wire with a linear regression analysis. Paired t-tests were used to compare data before and after embolization.

Results: There was a statistically significant but suboptimal correlation between the two methods (r = 0.36, N = 42, p>0.05). The Doppler measurements were positively biased in vessels with high pulsatility (χ2(1, N = 11) = 13.3, m = .55, b = 4.5, p>0.05). This might be related to the difference in data acquisition (average peak in Doppler vs spatially averaged velocity in 4D-DSA) or the flow dynamics of blood and contrast. 4D-DSA performed mid-embolization showed a global reduction in hepatic blood flow and velocity in the embolized liver when compared to preembolization (4.5 ± 0.7 vs 10.9 ± 1.9 cm/s, p = 0.008). Complete stasis was achieved in all cases, at which point reliable measurements could not be made using 4D-DSA due to low signal.

Conclusions: 4D-DSA can accurately reflect changes in hepatic arterial blood flow during TAE and it is a promising method for quantifying blood flow and velocity during angiography. While further work is needed to optimize the injection protocol and acquisition parameters, 4D-DSA may provide an objective, C-arm based means of determining angiographic endpoints during embolization.
Venous Access

Monday, March 19, 2018
3:00 PM–4:30 PM
Room: 409B

3:00 PM  Abstract No. 191

Risk factors for chest port infections in patients with solid cancers: multivariate analysis of 1158 patients

S. Zhang1, K. Kobayashi1, M. Faridnia2, P. Skummer3, D. Zhang4, M. Karmel5; 1SUNY Upstate Medical University, Syracuse, NY; 2N/A, Baldwinsville, NY; 3SUNY Upstate Medical University Hospital, Syracuse, NY, 4Upstate Medical University, Syracuse, NY

Purpose: To identify risk factors for chest port (port) infections in patients with solid cancers.

Materials: A retrospective chart review of 1158 adult patients (≥18 years old) with solid cancers (male/female: 551/607, mean age: 58.1 years) who had a port placed between January 2012 and December 2015 was conducted to identify patients port infections. Port placement was generally avoided in patients with severe neutropenia (absolute neutrophil count or ANC < 500/μL). The most frequent site of cancer was lung (n = 258, 22.3%) followed by breast (n = 240, 20.7%). Port infections included port site (local) and bloodstream infections. The patients were divided into two groups based on the records of port infections (infection vs non-infection). Variables including the patients’ demographics, medical history, laboratory data at the time of port placement, medication used, and port characteristics were compared between groups. To elucidate risk factors for port infections, multivariate proportional subdistribution hazard regression analyses were performed.

Results: A total of 389,815 catheter-days (median per patient: 522 catheter-days) were observed. Port infections were identified in 80 patients (6.9%) including 45 with port-site, 27 with bloodstream, and 8 with both. The infection rate was 0.21/1000 catheter-days. The median time to infection was 244 days (Range, 11-828 days). The infection group had significantly more patients with history of prior port placement (p = 0.01) and use of double lumen port (P = 0.001), and significantly shorter median duration of follow-up (P = 0.001) compared to the non-infection group. In backward stepwise multivariate analyses, prior port placement (p = 0.03, HR = 2.23, 95% CI [1.08-4.62]), use of double-lumen port (p = 0.01, HR = 2.08, 95% CI [1.15-3.74]) thrombocytopenia (platelet count < 150,000/μL) (p = 0.01, HR = 2.16, 95% CI [1.19-3.90]) remained statistically significant. Neutropenia (ANC < 1500/μL) was not the risk factor.

Conclusions: Solid cancer patients with thrombocytopenia or a history of prior port need to be closely monitored for port infections. A single lumen port would be advised in these subgroups.

3:09 PM  Abstract No. 192

Venous chest ports and thirty-day infection rates based on differences in access time after surgery

T. Tancredi1, P. Waybill2, F. Lynch3, J. Kissane3; 1Penn State Hershey College of Medicine, Hershey, PA; 2Penn State University, Hershey, PA; 3Penn State Hershey Medical Center, Hershey, PA

Purpose: To determine if there are differences in thirty-day risk of infection for the placement of chest ports, based on whether or not they are immediately accessed, or if they are accessed several days to several weeks after placement. While this has been assessed previously (Salazar et al), we aimed to do so with a larger sample set with greater statistical power.

Materials: This study is a retrospective chart analysis of patients who have undergone chest port placement between October 15, 2003, and June 10, 2015, at the Penn State Hershey Medical Center by the Department of Interventional Radiology. Thirty-day infection rates were compared for patients who had their ports accessed immediately after placement (i.e., in the procedure room post placement or on the same day as placement) versus patients who had their ports accessed greater than 24 hours after placement. Data was analyzed using the chi-square test and Fisher’s exact test. Logistic regression analysis was conducted to adjust for potential confounding effect of other risk factors, particularly those that are not balanced between the two groups.

Results: We analyzed 3322 port placements. 947 ports were immediately accessed, and 2375 were not immediately accessed. Of the ports that were subsequently found to be infected, 30 had been immediately accessed and 34 were accessed at a later date. The overall infection rate was 1.93% (64/3322), 3.17% (30/947) for immediate access, and 1.43% (34/2375) for non-immediate access. Chi-squared testing showed a p value of 0.0015 and Fischer’s exact Test showed a two-sided probability with a p value of 0.001013. This data supports a statistically significant difference in infection rates based on access. Chi-squared for dual- vs single-lumen infection rate demonstrated a p value of 0.028, consistent with data from previous studies which cited dual-lumen catheters as having a higher rate of infection that is statistically significant.

Conclusions: We have demonstrated with statistical significance that immediate access of ports more than doubles the rate of infection versus non-immediate access.

3:18 PM  Abstract No. 193

Clinical predictors of port infections in patients with hematologic malignancies

S. Zhang1, K. Kobayashi1, M. Faridnia2, P. Skummer3, D. Zhang4, M. Karmel5; 1SUNY Upstate Medical University, Syracuse, NY; 2N/A, Baldwinsville, NY; 3Upstate Medical University Hospital, Syracuse, NY; 4SUNY Upstate Medical University, Indianapolis, IN; 5Upstate Medical University, Syracuse, NY

Purpose: To identify clinical predictors of port infections in patients with hematologic malignancies.

Materials: A retrospective chart review of 223 adult patients (≥18 years old) with hematologic malignancies (male/female: 125/98, mean age: 54.5 years) who had a port placed between
January 2012 and December 2015 was conducted to identify patients with port infections. Port infections included port site and bloodstream infections. The patients were divided into two groups based on the records of port infections (infection vs noninfection). More than 20 variables including the patients’ demographics, medical history, laboratory data, medication used, and port characteristics were compared between groups. To elucidate clinical predictors for port infections, univariate and multivariate proportional sub-distribution hazard regression analyses were performed.

Results: A total of 83,722 catheter-days (median per patient: 272 catheter-days) were observed. Port infections were identified in 26 patients (11.7%) with an infection rate of 0.3/1000 catheter-days, including 4 with port site infections, 17 with bloodstream infections, and 5 with both. The median time to infection was 141 days (range, 7-858 days). The infection group had significantly higher use of steroids and shorter median duration of follow-up compared to the no infection group. Univariate analysis revealed acute myelogenous leukemia, steroid use, antiplatelet use, and neutropenia (absolute neutrophil count<1500/μL) to be possible predictors for port infections. In backward stepwise multivariate analyses, neutropenia and steroid use remained statistically significant with the adjusted hazard ratios for port infection of 2.41 (p = 0.048, 95% CI [1.01-5.75]) and 3.23 (p = 0.04). These infections can be devastating and lead to a delay in chemotherapy and result in open draining wounds further delaying care. Though placement of CPs on inpatients leads to higher rates of infections, there is no data to suggest if accessing an already implanted CP on inpatients confers an increased risk of infection. Therefore, this study aims to evaluate the infection rate of patients who have their CPs accessed in the inpatient setting.

Materials: This IRB retrospective chart review utilized a QA/QI database to determine a cohort of patients with CPs placed between January 2006 and December 2016. The patients were stratified into two groups, those admitted to the hospital and had their CPs accessed during their hospitalizations and those that were hospitalized and did not have their CPs accessed. Patient records were reviewed to obtain data regarding CP related infections. Additionally, the nurses accessing the CPs were also noted, i.e., ward nurses vs. specialized trained nurses or venous access team members (VAT). Infection rates between the two subgroups were then determined.

Results: Of the 100 patients analyzed to date, there was a total rate of infection of 6% (6/100). 66 had their CP accessed during an inpatient hospitalization and of those, 6 developed CP related infections 9% (6/66). The general ward nurses accessed 60 of those CPs, while the VAT members accessed 6 CPs. All 6 patients that developed infections had their CP accessed by ward nurses. The 34 patients who did not have their CP accessed as inpatients did not develop any CP related infections.

Conclusions: Preliminary data suggests infection rates are increased when CPs are accessed during inpatient hospitalization. It remains to be seen if there is a significant correlation for higher rates of infections with ward nurses accessing the CP compared to VAT members.

3:27 PM Abstract No. 194

Does accessing chest ports during inpatient hospitalization increase risk of catheter-based infection?
D. Joshi1, E. Hohenwalter1, J. Riesenberg2, S. White1; 1Medical College of Wisconsin, Milwaukee, WI; 2Froedtert Memorial Lutheran Hospital, Milwaukee, WI

Purpose: Since their advent in 1982, chest ports (CPs) have become the standard of care for administering chemotherapy to cancer patients. It has been shown that placing chest ports during an inpatient hospitalization portends an increased risk of infection. These infections can be devastating and lead to a delay in chemotherapy and result in open draining wounds further delaying care. Though placement of CPs on inpatients leads to higher rates of infections, there is no data to suggest if accessing an already implanted CP on inpatients confers an increased risk of infection. Therefore, this study aims to evaluate the infection rate of patients who have their CPs accessed in the inpatient setting.

Materials: This IRB retrospective chart review utilized a QA/QI database to determine a cohort of patients with CPs placed between January 2006 and December 2016. The patients were stratified into two groups, those admitted to the hospital and had their CPs accessed during their hospitalizations and those that were hospitalized and did not have their CPs accessed. Patient records were reviewed to obtain data regarding CP related infections. Additionally, the nurses accessing the CPs were also noted, i.e., ward nurses vs. specialized trained nurses or venous access team members (VAT). Infection rates between the two subgroups were then determined.

Results: Of the 100 patients analyzed to date, there was a total rate of infection of 6% (6/100). 66 had their CP accessed during an inpatient hospitalization and of those, 6 developed CP related infections 9% (6/66). The general ward nurses accessed 60 of those CPs, while the VAT members accessed 6 CPs. All 6 patients that developed infections had their CP accessed by ward nurses. The 34 patients who did not have their CP accessed as inpatients did not develop any CP related infections.

Conclusions: Preliminary data suggests infection rates are increased when CPs are accessed during inpatient hospitalization. It remains to be seen if there is a significant correlation for higher rates of infections with ward nurses accessing the CP compared to VAT members.

3:36 PM Abstract No. 195

Chest port placement in patients with a history of port removal: is there any difference in the incidence of complications between ports placed in the same and opposite side of chest wall as the prior port?
D. Sun1, K. Kobayashi1, M. Samuel2, P. Skummer1, S. Zhang1, D. Zhang1, M. Karmel1; 1SUNY Upstate Medical University, Syracuse, NY; 2Stony Brook School of Medicine, Stony Brook, NY

Purpose: To retrospectively compare the incidence of chest port (port)-related complications in patients with repeat ports placed in either the same or opposite side of chest wall as the prior port.

Materials: Of a total of 1736 ports placed in oncologic patients between January 2012 and July 2016, 82 patients (M/F: 48/34, median age: 56 years) had a history of prior port placement and removal. The chest wall on the side of the prior port was intact at the time of new port placements. Of these, 48 ports were placed in the same side as the prior port (same side group) and 34 ports were placed in the opposite side (opposite side group). Indications of prior port removal were completion of chemotherapy (n = 24), port complications (n = 55), and other (n = 3). The median interval between prior port removal and new port placement was 58 days. The medical records and imaging studies were reviewed to identify port complications including (local and blood stream) infectious, mechanical, venous thrombotic, and port-site skin issues. Incidences of complications were compared between groups and risk factors for complications were elucidated.

Results: The median follow-up was 202 catheter-days. A total of 11 patients (22.9%) in the same side group and 2 patients (5.9%) in the opposite side group had complications (p = .04). No statistical difference was found in the incidence of infectious (7/48 vs. 2/34, p = .29), mechanical (2/48 vs. 0/34, p = .51), thrombotic (1/48 vs. 0/34, p = 1.0), and port-site skin (2/48 vs. 0/34, p = .51) complications. The use of same side of chest wall (OR = 4.76, 95%CI
[0.98–23.08], p = .05) and a history of prior port thrombosis (OR = 3.84, 95% CI [0.79–18.62], p = .10) were possible risk factors for complications in repeat port placement in univariate logistic regression analysis.

**Conclusions:** Placing a new port on the same side of chest wall as the prior port may increase the risk of complications compared to placement in the opposite side. Repeat port placement on the opposite side of chest wall is advised for patients with a history of port-related venous thrombosis.

**3:45 PM Abstract No. 196**

**Nontunneled central apheresis catheter placement for T-cell harvesting in chimeric antigen receptor therapy: 5-year experience at a pediatric institution**

C. Maya1, C. Barrera1, A. Srinivasan1, S. Vatsky1, M. Acord1, F. Escobar1, S. Grupp1, S. Maude1, H. Kim1, A. Cahill1; 1The Children’s Hospital of Philadelphia, Philadelphia, PA

**Purpose:** The use of modified T-cells with CD19/22 directed chimeric antigen receptors (CTL019) is a new strategy for the treatment of relapsed and refractory acute lymphoblastic leukemia. High flow central venous catheters are required for harvesting. This study analyzes our experience with centrally placed apheresis catheters in this pediatric population.

**Materials:** A retrospective review of nontunneled apheresis catheter placement since 2012 (CTL019 trials began) yielded a total of 426 cases. Leukapheresis for CTL019 was the indication in 112.

**Results:** Technical success was 100% for 112 catheters placed in 95 subjects. Demographics include: 53 males, 42 females with median age of 12.5 years (3.4–24.9 years). The intention for catheter placement was CTL019 infusion; however, 7/112 (6%) catheter placements were ultimately not followed by therapy. Four of the 7 subjects died pre T-cell infusion, 1/7 underwent a BMT in the interim, requiring a repeat harvesting and in 1/7 the T-cell modification failed. Procedures were performed under general anesthesia and IV sedation in 56/112 (50%) each. The majority were outpatient 90/112 (80%). Venous access sites were: right internal jugular vein 100/112 (89%), right femoral vein (RFV) 7/112 (6%), left internal jugular vein 3/112 (3%) and left femoral vein 2/112 (2%). There was one failed catheter placement due to superior vena cava stenosis, ultimately placed via the RFV. Double lumen catheters used were: Medcomp® 90/112 (80%), Mahurkar™ 20/112 (18%) and Arrow™ 2/112 (2%) with external diameters of 8 Fr, 25/112 (22%), 9 Fr, 30/112 (27%) and 11.5 Fr, 57/112 (51%). Mean fluoroscopic time was 88 seconds (6–1086 secs) and the average dose area product was 34.38 mGy/m² (0.16–1279.3). The average duration of catheter insertion was 41.6 hours (1.3–179.7 hours). There were no intra-procedural complications. Post procedure complications included, self-limited site oozing in 2/112 (2%) catheters, pain in 2/112 (2%) and catheter repositioning in 1/112 (1%).

**Conclusions:** Central venous nontunneled apheresis catheters for T-cell harvesting, in children with ALL, have a high technical success and low complication rate and can be safely performed as an outpatient.

**3:54 PM Abstract No. 197**

**Chest port-related venous thrombosis: incidence and risk factors**

S. Jetty1, K. Kobayashi1, H. Wady1, S. Zhang1, P. Skummer2, M. Karmel2; 1SUNY Upstate Medical University Hospital, Syracuse, NY; 2Upstate Medical University, Syracuse, NY

**Purpose:** To retrospectively investigate the incidence of chest port (port)-related venous thrombosis (PVT) and to elucidate the risk factors.

**Materials:** Between January 2013 and December 2015, a total of 871 ports were placed in 871 patients with solid cancers (n = 825) and chronic medical disease (CMD) (n = 46). CMD included sickle cell disease (n = 9), cystic fibrosis (n = 5), and iron deficiency anemia (n = 5) and others (n = 27). Patients with port-associated venous thrombosis were identified through chart and imaging review. The patients were divided into two groups based on the records of PVT (PVT group vs Non-PVT group). More than 20 variables including the patients’ demographics, medical history, laboratory data, medication used, and port characteristics were compared between groups. To elucidate risk factors for PVT, univariate analysis was performed using proportional hazards regression model for the sub-distribution of a competing risk.

**Results:** A total of 269,482 catheter-days (median per patient: 244 catheter days) were observed. A total of 23 PVT (2.6%, 0.09/1000 catheter-days) were observed, including 19 symptomatic (82.6%) and 4 asymptomatic (17.4%). The median time to thrombosis was 120 days. Of these, one was associated with pulmonary embolism. Location of PVT include superior vena cava (n = 7, 21.9%), internal jugular vein (n = 11, 37.4%), brachiocephalic vein (n = 5, 18.8%), subclavian vein (n = 4, 12.5%), and others (n = 4, 12.5%). More than one vein was affected in 7 patients (30.4%). No significant difference in patient or port characteristics was seen between groups except for medical history (solid cancers vs CMD, P = 0.03). In univariate analysis, patients with CMD were at a significantly higher risk of PVT than those with solid cancers (hazard ratio: 2.749; 95% CI: 1.01–7.51; p = 0.049). Other variables were not statistically significant for port-associated thrombosis.

**Conclusions:** PVT was a relatively rare complication. Patients with CMD were at a higher risk of PVT than those with solid cancers.

**4:03 PM Abstract No. 198**

**Comparison of infection and dysfunction risks of internal jugular versus femoral tunneled hemodialysis catheters**

N. Befera1, T. Smith1, B. Engstrom2, J. Ronald1, D. Sopko1, W. Pabon-Ramos1, C. Kim1; 1Duke University Medical Center, Durham, NC; 2N/A, Minneapolis, MN

**Purpose:** While there is robust data comparing outcomes for temporary catheters in the ICU based on insertion site, there is a
paucity of literature on long-term catheters, which may be subject to different environmental and patient-related factors. Therefore, the purpose of this study was to compare rates of infection and dysfunction for tunneled hemodialysis catheters inserted via the femoral versus internal jugular veins.

Materials: Review of our procedural database for tunneled hemodialysis catheter insertions in either the common femoral vein or internal jugular vein revealed a total of 544 patients (294 male, 250 female; mean age 55.6 years). Demographic information was recorded as well as presence or absence of comorbidities at time of catheter placement. The date and reason for removal or catheter exchange was ascertained from the medical records. The freedom-from-infection or dysfunction intervals were calculated with the Kaplan-Meier technique and compared with the logrank test.

Results: Analysis was performed on 409 internal jugular vein catheters and 134 femoral catheters. There was no significant difference between the two groups in proportion of patients with diabetes, HIV, steroids, chemotherapy, or cancer. History of DVT/PE was present in 21% of patients with femoral catheters, vs 14% of patients with IJ catheters (p = 0.08). The median infection-free interval for IJ catheters was 363 days, compared with 174 days for femoral catheters (p = .007). The infection rate was 0.38 per 100 catheter days for the femoral group, compared with 0.20 for the IJ group. The mean dysfunction-free interval was 862 days for IJ catheters vs 520 days for femoral catheters (p = .09). The dysfunction rate was 0.21 per 100 catheter days for the femoral group, compared with 0.10 for the IJ group.

Conclusions: The catheter-associated infection rate was significantly higher for patients with tunneled femoral hemodialysis catheters versus IJ catheters but with a similar dysfunction rate. However, the infection rate for femoral catheters is well within the acceptable rate for catheter-related infection.

4:12 PM Abstract No. 199

Evaluating flow dynamics in arteriovenous dialysis fistulae stenoses: a model to better understand flow dynamic significance
K. Anton1, D. DeColli2, J. Tranquillo2, A. Patel2; 1Thomas Jefferson University Hospital, Philadelphia, PA; 2Bucknell University, Lewisburg, PA

Purpose: Arteriovenous (AV) fistula creation, the preferred access for renal replacement therapy alters flow dynamics in the associated vasculature, most significantly in the veins. Increased venous pressure (arterialization) leads to desired vessel remodeling/maturation but unwanted focal venous stenoses. Not all stenoses (especially central venous stenosis) require dilation despite luminal narrowing. We hypothesize that a lumped circuit model can simulate and improve understanding of how venous outflow stenoses alter AV fistula flow dynamics.

Materials: A lumped electrical circuit model of flow in upper extremity vasculature was developed and simulated using MATLAB Simulink software. Brachiocephalic and radiocephalic fistula anatomy was translated to a circuit model to study approach feasibility. Published data for vessel diameter and vessel compliance were incorporated into a two-element Windkessel model of vessels. Variations in current (flow) at the site of puncture with changes in central venous resistance (stenosis) were evaluated using the solved model. The resulting current (flow at puncture site) for each change in resistance at the brachiocephalic vein were plotted and compared for the brachiocephalic and radiocephalic AV fistula models.

Results: A decrease in central brachiocephalic vein diameter by 85% (brachiocephalic fistula) and 78% (radiocephalic fistula) is required to achieve a significant change in current (flow) across the AV fistula. Stenoses (increased resistance) less than 85% in the brachiocephalic and 78% in the radiocephalic models did not significantly reduce the venous outflow (current) from the fistula.

Conclusions: A simplified lumped circuit model can be used to represent the complex flow dynamics of an arteriovenous fistula to better understand the effects of stenoses on blood flow. The upper arm models suggest that severe central luminal narrowing is required to produce a clinically significant change in flow dynamics across the fistula. This is consistent with cases seen in clinical practice and suggests many central stenoses angioplastied during fistulography may not be flow limiting. This model further supports published evidence that not all stenoses should be treated.

4:21 PM Abstract No. 200

Cost analysis of portable versus interventional radiology suite tunneled femoral central venous catheter placement in infants and toddlers
A. Cantos1, T. Baran2, Y. Chang2, J. Reis3; 1University of Rochester/Strong Memorial Hospital, Rochester, NY; 2University of Rochester Medical Center, Rochester, NY; 3University of Rochester Strong Memorial Hospital, Rochester, NY

Purpose: To compare the procedural cost of pediatric tunneled femoral non-cuffed central venous catheter (CVC) placement at the bedside to placement in the interventional radiology (IR) suite.

Materials: A retrospective chart review was performed of infants and toddlers who underwent IR tunneled femoral CVC placement between 2015 and 2017. All catheters placed were Vascu-PICCs (Medical Components, Inc.; Harleysville, PA). Complications, total catheter days, re-insertions and billed procedural costs were recorded. Procedural costs included professional, equipment, room, and ancillary technical fees. Complication rates were compared using multivariate Cox Regression analysis. The mean cost per procedure was compared using a Mann-Whitney test. The bundled mean cost per patient was also compared to account for catheter re-insertion related to a complication.

Results: Sixty-three insertions were performed on 55 patients, including 26 bedside procedures and 37 IR suite procedures. The overall catheter infection rate was 0.67 per 1000 catheter days. There were no significant differences in catheter infection (p = 0.41) or overall complication (p = 0.93) rates between bedside and IR suite placement. The mean procedural cost at the bedside of $3,649 was significantly lower than the IR suite cost of $4,803 (p = 0.002). The mean bundled cost per patient at the bedside of $3,759 was significantly lower than the IR suite cost of $5,227 (p = 0.006).

Conclusions: Tunneled femoral CVC placement for infants and toddlers at the bedside is significantly lower in cost than in the IR suite and should be considered as an alternative option whenever possible.
Scientific Session 21

Embolization: Musculoskeletal

Monday, March 19, 2018
3:00 PM–4:30 PM
Room: 410

3:00 PM Abstract No. 201

Classification of geniculate artery anatomy and implications for geniculate artery embolization: experience from a U.S. pilot study
S. Bagla¹, R. Piechowiak¹, J. Orlando¹, T. Hartman², A. Isacsson³, ¹Vascular Institute of Virginia, Woodbridge, VA; ²UNC Chapel Hill, Chapel Hill, NC; ³University of North Carolina, Chapel Hill, NC

Purpose: There is limited detailed geniculate artery anatomy described in the literature. With recent [1] and ongoing studies demonstrating success with GAE in alleviating pain secondary to knee osteoarthritis (OA), the investigators aim to detail angiographic findings and anatomical variants in OA in patients undergoing GAE. We also suggest a classification system based on anatomical pattern (Class M/L).

Materials: 20 patients are being enrolled in a Multicenter US pilot study (clinicaltrials.gov NCT02850068) to investigate the effects of GAE on pain associated with knee OA. Angiographic images from 14 subjects were reviewed for: angiographic appearance, presence or absence, location of origin, and variation patterns of typical geniculate arteries were noted. Presence or absence of each of the six common genicular branches was also noted including the descending genicular artery (DGA), medial superior geniculate artery (MSGA), medial inferior genicular (MIGA), lateral superior genicular artery (LSGA), lateral inferior genicular artery (LIGA), and anterior tibial recurrent artery (ATRA). Based on the branching patterns observed a classification system is proposed.

Results: Abnormal focal hypertrophy was noted in the area of palpable pain in all subjects. The descending genicular (DGA) was observed in all cases, the medial superior genicular (MSGA) observed in 57%, and the medial inferior genicular (MIGA) observed in 86%. All three medial branches were present in 7/14 (Class M1). In cases when the MSGA was absent or diminutive, the DGA was larger in caliber (class M2). The lateral superior genicular artery (LSGA) was observed in 79%. The lateral inferior genicular artery (LIGA) was observed in 86% and the anterior tibial recurrent artery (ATRA) in 71%. All three lateral branches present in 9/13 (Class L1). The LIGA was the solitary supply 3/14 cases (Class L2). There was a common origin to MSGA and LSGA in 4/14 cases.

Conclusions: A thorough understanding of geniculate artery anatomy is necessary to target hyperemic synovium during embolization for pain relief. The variations and classification system described are useful in gaining this understanding.

3:09 PM Abstract No. 202

Embolization of genicular arteries for chronic hemarthrosis post knee prosthesis
O. D’Archambeau¹, E. Luyckx¹, T. Van der Zijden¹, M. Voormolen¹, ¹University Hospital Antwerp Antwerp, Belgium

Purpose: Postoperative hemarthrosis after knee prosthesis can be invalidating due to painful swelling of the knee and diminished mobility. We describe the technique and clinical results of endovascular embolization of genicular arteries performed over a 10-year period.

Materials: A retrospective review of 31 patients (17 male, 14 female) treated for chronic knee hemarthrosis from 01.2007 until 12.2016 was performed. The mean age was 67y (range, 48-90). A total of 39 embolization procedures were performed (24 single, 6 double and 1 triple), 27 right and 12 left sided. The mean time from surgery to symptoms was 24.4 months (range, 1-64) and to embolization was 27.4 months (range, 1-70). Surgery type was total-knee prosthesis (TKP) in 29 patients, unicompartmental (UC) prosthesis in 2. The mean follow-up was 61.9 months (range, 2 - 120). The technical approach was ipsilateral (antegrade femoral) in 34 procedures and contralateral in 5. All embolizations were performed using 4F diagnostic catheters, 2.7F microcatheters and microspheres ranging from 100 - 500μ. The technical endpoint was subtotal devascularization in order to avoid ischemic complications. Clinical endpoint was symptomatic improvement.

Results: Technical success was achieved 100%. In all cases, the superior lateral and medial genicular arteries could be embolized. In 12/39 procedures (31%), one or both inferior genicular arteries could not be catheterized due to the superposition of the TKP. Embolization was then performed through collaterals. Symptomatic improvement was achieved in 26/31 patients (84%). Symptomatic recidive was more frequent with larger particles (up to 500μ). Postprocedural pain was observed in all patients, treated with paracetamol, resolving inside 24 hours in most. Smaller particles (100μ) resulted in more severe pain. Therefore, particular size of 250μ is preferred. Two complications occurred, one low grade infection and one aseptic necrosis requiring surgical revision. No peripheral emboli were noted.

Conclusions: Endovascular embolization of genicular arteries is safe and effective for the treatment of chronic hemarthrosis post knee prosthesis placement. Clinical improvement is seen in most patients. Complications are rare.

3:18 PM Abstract No. 203

Selective geniculate artery embolization for management of recurrent hemarthrosis after total-knee arthroplasty
J. Cornman-Homonoff¹, S. Kishore¹, B. Waddell², G. Westrich², H. Potter², D. Trost¹, ¹NewYorkPresbyterian/Weill Cornell Medical Center, New York, NY; ²Hospital for Special Surgery, New York, NY

Purpose: Recurrent hemarthrosis occurs in 1.6% of patients following total-knee arthroplasty (TKA), and may cause painful knee swelling, stiffness, and functional limitation. The most common cause is impingement of hypertrophic synovium between
prosthetic articulating surfaces. Geniculate artery embolization (GAE) is a promising minimally-invasive treatment in cases where conservative measures fail. We describe technical details, outcomes, and complications of GAE performed at a single institution for recurrent hemorrhage in the setting of prior TKA.

**Materials:** Records were reviewed for all patients who underwent GAE for treatment of recurrent hemorrhage post TKA between March 2010 and July 2017. Hemorrhage was confirmed by joint aspiration in all cases. Patients with pseudoaneurysm or mechanical prosthetic malfunction were excluded. Demographics, technical details, complications, and outcomes were ascertained via chart review and directed patient interview.

**Results:** 72 GAE performed in 51 patients (29 male, 22 female; mean age 66, range 41-86) were included. Time to symptom onset averaged 16 months (range, 0-128). An average of 2.1 arteries were embolized per initial GAE, most commonly superior lateral geniculate (48 cases, 92%) and inferior lateral geniculate (33 cases, 63%). Embosphere particles sized 100-700 um were used, most commonly 100-300 um in 51 GAE (98%). Joint aspiration was performed in 46 GAE (88%) and steroid injection in 21 (40%). Fluoroscopy time averaged 27.8 minutes (range, 11.7-66.3). Technical success was achieved in all cases without serious complications. Periprocedural transient cutaneous ischemia occurred in 7 cases (13%). 20 repeat GAE were performed in 17 patients (33%). Follow-up was available for 37 patients over an interval of 1052 days (range, 7-4117 days). Of these, 86% reported symptomatic and functional improvement.

**Conclusions:** Targeted GAE with spherical particles is an effective treatment for recurrent hemorrhage following TKA with infrequent and minor complication. Repeat embolization should be offered in cases of recurrence following initial therapy. GAE should be considered as a first-line treatment following failure of conservative management.

---

**3:27 PM Abstract No. 204**

**Cost analysis of geniculate artery embolization versus conservative therapy for pain secondary to knee osteoarthritis**

E. Davies1, A. Isaacson1; 1University of North Carolina, Chapel Hill, NC

**Purpose:** Osteoarthritis (OA) of the knee is a painful and common condition imposing a substantial economic burden on the United States. Because the pathophysiology of knee OA is poorly understood, the first-line approach to management is regular NSAID administration, targeting generalized pain pathways. This regimen exposes patients to a heightened risk of costly and complicated adverse events. Geniculate artery embolization (GAE) has emerged as a minimally-invasive therapy to reduce vascularity in the synovial joint of the arthritic knee. Initial data suggests that this procedure improves patients’ functional status and reduces pain. This study estimates the cost of GAE from the perspective of UNC Hospitals using institutional data.

**Materials:** The study compares the cost estimate of GAE to the baseline expense of two-year regimens of conservative medical management using publicly available drug prices in the Chapel Hill, NC area. A review of relevant literature was conducted to assess the probability and costs of conservative therapies’ complications. Markov models predicted a forecast of the cost of complications of the 95th percentile of patients, which was compared to the expected cost of GAE.

**Results:** The analysis found that, at baseline, hylan G-F 20 injections ($6,056.00) are more expensive than GAE ($3,095.75), non-selective NSAIDs ($48.00), COX-2 selective NSAIDs ($341.28), and acetaminophen ($36.79). When the 95th percentile of complications were compared, COX-2 selective NSAID regimens were most expensive ($15,971.00), followed by GAE ($6,191.50), hylan G-F 20 injections ($6,056.00), non-selective NSAIDs ($594.00), and acetaminophen ($36.79).

**Conclusions:** GAE is more expensive than most conservative medical management options for mild-to-moderate knee OA, even when future complications are considered. Conclusive evidence of the long-term efficacy of this therapy is not yet available. Long-term follow-up data is needed so that GAE can be compared against existing therapies in terms of quality-adjusted life years rather than expected cost.

---

**3:36 PM Abstract No. 205**

**Impact of contrast-enhanced magnetic resonance imaging on clinical outcomes of transcatheter arterial embolization for chronic musculoskeletal pain**

T. Yasumoto1, K. Uemoto1, K. Yamada1, D. Tatsumi1, R. Oh2; 1Miyakojima IGRT Clinic, Osaka, Japan

**Purpose:** To evaluate the contrast enhancement around the joint and the correlation with therapeutic effect for refractory chronic musculoskeletal (MSK) pain by comparing the contrast-enhanced magnetic resonance imaging (MRI) before and after transcatheter arterial embolization (TAE).

**Materials:** This retrospective study included 92 lesions of 73 consecutive patients persisting moderate to severe MSK pain that was resistant to conservative management. These patients were treated with TAE in our clinic between September 2015 and August 2017. TAE was performed with imipenem/cilastatin sodium suspended with contrast material. Contrast-enhanced MRI was performed before and after treatment. Two radiologists specialized in MSK evaluated the contrast enhancement of the synovial tissue around the joint with the signal intensity in a region of interest on fat-suppressed enhanced T1-weighted images, as a blind study. Reduction of contrast enhancement was classified into three groups; A: invariant, B: mild, C: marked. Numerical rating scale (NRS) was examined among the three groups.

**Results:** There were no major adverse events related to the procedures. The median follow-up period was 12 months. No significant observer bias was detected by kappa values of 0.74 (95% CI = 0.61–0.80). The mean NRS score decreased from 8.1 to 5.9 in group A (12% (11/92 lesions)), 8.3 to 4.3 in group B (49% (45/92 lesions)), and 9.2 to 2.5 in group C (39% (36/92 lesions)), respectively. The mean NRS score decreased significantly in group C compared with group A (P < 0.05).

**Conclusions:** Contrast-enhanced MRI could be considered as a useful examination for judging the effect of TAE for chronic MSK pain.
3:45 PM Abstract No. 206

Magnetic resonance imaging finding in patients undergoing geniculate artery embolization (GAE) for osteoarthritis-related knee pain: results from a multicenter U.S. trial

S. Bagla1, A. Isaacson2, R. Piechowiak3, T. Hartman4, J. Orlando5, D. Nissman6; 1Vascular Institute of Virginia, McLean, VA; 2University of North Carolina, Chapel Hill, NC; 3Vascular Institute of Virginia, Arlington, VA; 4UNC Chapel Hill, Chapel Hill, NC; 5N/A, Manassas, VA

**Purpose:** Knee OA is a common cause of pain and disability, with many patients relying on chronic pain medications, which are associated with gastrointestinal and renal toxicity. Knee replacement surgery may be performed in late stages. Recent discovery suggests MRI findings of synovial thickening and enhancement correlate with knee pain in OA. As part of a U.S. pilot study evaluating GAE we performed MRI to assess the safety of embolization as well as evaluate its effects on synovial enhancement.

**Materials:** 14/20 patients have been enrolled in an IDE/IRB approved multicenter U.S. pilot study (clinicaltrials.gov NCT02850068) to investigate the effects of GAE on pain associated with knee OA. MRI with gadolinium contrast was performed before and 1 month after GAE. MR images from subjects were reviewed for: presence or absence of synovial enhancement, marrow changes and evidence for non-target ischemia. 8/14 patients underwent 1-month follow-up to date.

**Results:** Medial compartment pain was seen in 79% (11/14), 14% lateral and 7% medial/lateral. Synovial enhancement and thickening was noted in 100% of subjects, and was present at the site of palpable pain in all patients. 88% (7/8) of subjects demonstrated decreased synovial enhancement in the area of embolization compared with preprocedure. One subject was lost to follow-up and 5 subjects are pending postprocedure MRI. One subject’s postprocedure MRI demonstrated small patchy non-specific marrow changes at the metaphysis.

**Conclusions:** Geniculate artery embolization typically results in decreased synovial enhancement at the site of embolization. However, bone marrow changes can be seen early after GAE.

3:54 PM Abstract No. 207

Identifying risk factors for rebleeding after embolization for rectus sheath hematoma

H. Chan1, A. Hsu1, J. Angle1; 1University of Virginia, Charlottesville, VA

**Purpose:** To identify risk factors for rebleeding in patients with rectus sheath hematoma (RSH) who have undergone arterial embolization.

**Materials:** Retrospective chart review was performed on patients who underwent embolization for RSH from 2009 to 2017 in one institution. Pertinent data were collected from the EMR and PACS. T-test, Mann-Whitney, and Fisher’s exact test were performed with p<0.05 indicating statistical significance.

4:03 PM Abstract No. 208

Spontaneous rectus sheath hematoma: factors predictive of conservative management failure

B. Contrella1, A. Park2, L. Wilkins3, D. Sheeran4, H. Chan1, J. Angle1; 1University of Virginia, Charlottesville, VA; 2UVA Health System, Charlottesville, VA; 3University of Virginia, Charlottesville, VA; 4University of Virginia Health System, Charlottesville, VA

**Purpose:** To evaluate radiographic, laboratory, and clinical factors associated with failure of conservative management of spontaneous rectus sheath hematoma (RSH), and to develop parameters to guide decisions on the need for intervention.

**Materials:** All patients at a single academic institution with image-proven spontaneous RSH over an 11-year study period were retrospectively reviewed. All patients were initially managed conservatively, then divided into 2 groups based on the clinical decision to proceed to embolization. Univariate statistical analysis was performed to compare demographic and outcome variables between the two groups. A multivariable logistic regression was performed to identify factors predictive of failure of conservative management for spontaneous RSH.

**Results:** Seventy-two patients with spontaneous RSH were identified during the study period. Failure of conservative therapy was seen in 32 (44%) patients, and 3 patients required an
additional embolization procedure. No significant demographic differences were identified between the embolization and conservative management groups. Multivariable logistic regression identified active extravasation on computed tomography (CT) scan (p = 0.01), hematoma volume greater than 1300 mL (p = 0.01), transfusion of 3 or more units of packed red blood cells (pRBC) (p = 0.04), and maximum rate of hemoglobin drop greater than 0.25 g/dL per hour (p = 0.01) as predictors of need for embolization. Using these parameters, a scoring system was created to predict failure of conservative management. Application of the scoring system to patients in the study population yielded a sensitivity of 100% and specificity of 98% in determining need for embolization.

**Conclusions:** A considerable number of patients with spontaneous RSH included in this analysis failed conservative management. Using common clinical and imaging parameters, a scoring system was established that successfully correlated with patients with RSH who were likely to escalate to embolization. This scoring system may be useful as a tool to predict need for embolization in future patients, though further prospective study is required.

**4:12 PM Abstract No. 209**

**Neovascularization in knee osteoarthritis: a new mouse model using micro computed tomography to delineate pathological vascular remodeling**

R. Talaie1, M. Richards1, H. Krug2, C. Dorman3, S. Noorbalochoo2, J. Golzarian1; 1University of Minnesota, Minneapolis, MN; 2University of North Carolina, Chapel Hill, NC; 3Minneapolis VA Health Care System, Minneapolis, MN

**Purpose:** To identify new arterial branches in a murine model for osteoarthritis

**Materials:** Knee osteoarthritis (OA) is a common disease with significant morbidity (1). Treatment includes oral anti-inflammatory, intraarticular knee injection, and surgical arthroplasty. New theories propose increased hypervascularity of the joint and periarticular tissue. Some authors argue that homeostasis is tilted in knee OA to favor inflammation and hypervascularity; however, no animal model has demonstrated any discrete hypervascularity beyond a microscopic range. Limited human trials have been conducted studying embolization of unnamed arterial branches in juxta-articular tissues to treat pain (4). There has been no proof for causality of OA for new large angiographically evident arterial branches. We describe a murine model of knee OA hypervascularity by intraarticular collagenase injection. 18 animals were divided to groups of six. OA was induced in all left limbs and the right limbs served as control. Animals ambulated ad lib. The mice were sacrificed at 4, 8, and 12 weeks post injection. After deep sedation; via tail vein access 0.6 mg of papaverine was used for vasodilation followed by 100 U of heparin. Animals were sacrificed and median thoracolaparotomy was performed, followed by IVC transection and left ventricular cannulation to allow for sequential perfusion with phosphate buffered saline, paraformaldehyde, and a lead chromate based casting agent. After polymerization overnight, the hindlimb was dissected and scanned by μCT at 45 kVp, 177 μA, 200 ms integration time, and a voxel size of 16 μm. Unnamed branches of murine hindlimb arteries were counted from the last trifurcation of femoral artery through 2.5 mm below the tibial plateau.

**Results:** Experimental limbs had more branches than controls (mean of 11.6 vs 7.5; p < 0.001), with an effect size of 1.3 (95% CI: 1.06-1.76). Time by group approached significance (p = 0.09). Interaction between intervention and time was not significant (p = 0.17).

**Conclusions:** There is increased number of arterial branch vessels associated with knee OA in a murine model, similar to target vessels that have been embolized in human subjects.

**4:21 PM Abstract No. 210**

**Geniculate artery embolization for osteoarthritis-related knee pain: interim results from a multicenter U.S. trial**

S. Bagla1, R. Piechowiak1, T. Hartman2, J. Orlando1, A. Isaacs3; 1University of Virginia, Woodbridge, VA; 2UNC Chapel Hill, Chapel Hill, NC; 3University of North Carolina, Chapel Hill, NC

**Purpose:** Knee OA is a common cause of pain and disability, with many patients relying on chronic pain medications and/or joint injections. These options unfortunately result in short-term relief, or have associated increased morbidity, and knee replacement surgery may ultimately be performed. Researchers have postulated that synovial neovascularity develops as a result of inflammation and subsequently leads to knee pain. While previous overseas reports of success with GAE have been published, we present our interim results from a prospective US multicenter clinical trial.

**Materials:** 20 subjects with OA with pain greater than 50 mm (Visual Analog Scale 100 mm) refractory to conservative therapy are being recruited for the study (clinicaltrials.gov NCT02850068). Subjects were excluded for: Kellgren Lawrence (KL) Stage 4, rheumatoid arthritis, infection, previous arthroplasty, renal insufficiency, or uncorrectable coagulopathy. GAE was performed using 75 or 100 um microspheres in 13 subjects at 2 US centers. Subjects were assessed with MRI, Visual Analog Scale (VAS) refractory to conservative therapy were assessed on clinical data, WOMAC, VAS, and global outcomes. Median baseline OA was KL stage III. Neovascularity was identified in the area of pain in all cases by arteriography (n = 13) and GAE was technically successful in all subjects (n = 13). 8/13 subjects were eligible for clinical follow-up at present. GAE significantly improved pain at 1 month as measured by VAS (n = 8, mean -58 mm, p = 0.016). Global WOMAC score also decreased (n = 8 mean -36.3, p = 0.0008). No major adverse events were seen related to the procedure.

**Conclusions:** Interim results are promising for GAE to safely reduce pain and disability for mild to moderate knee osteoarthritis.
Design of an MRI-guided robotic prostate intervention
P. Kulkarni¹, P. Biswas¹, S. Sikander¹, H. Dehghani¹, J. Burt², S. Song¹; ¹University of Central Florida, Orlando, FL; ²Florida Hospital, Orlando, FL

Purpose: MR image to in-bore intervention registration requires complex technical steps thus resulting in prolonged procedure time for MRI-guided prostate interventions. Such limitations have prevented widespread implementation of MRI-guided targeted prostate biopsy despite the advantages of MRI compared to TRUS. Current MRI-guided interventions have a complex design for providing angulated insertion. We have designed a compact MRI-guided robotic intervention that can eliminate the need for image-to-device registration with angulated needle insertion capability.

Materials: The system consists of a novel mechanism driven Robotic Needle Guide (RNG) and a Planning Workstation (PW). The RNG is a 4-DOF robotic needle manipulator mounted on a Gross Positioning Module (GPM), which is locked on the MRI table. Since, MRI table movement is precisely controlled, location and encoded kinematic configuration of the RNG and GPM can be fully digitized along with anatomical features of the patient. When a clinician selects a needle insertion target, the intervention provides possible needle insertion angles forming a cone from the target. Then, the most suitable angle is selected based on the safest anatomical trajectory. The selected target and insertion angle are then computed as control parameters of RNG. Once inserted, a quick confirmation image is acquired to ensure the needle is on target. Such confirmation scans update the latest target location so that re-registration is not needed.

Results: Our motion simulation study of the RNG validates feasibility of simultaneous motion of the GPM with the MRI table. It demonstrates that the 4-DOF robotic manipulator can freely provide angulated needle insertion. The current design provides 15 degrees of angulation based upon other studies.

Conclusions: Digitized manipulation of a robotic intervention locked on the MRI table can eliminate error prone and time-consuming registration steps including additional scans and MR visible markers. Such an approach is also robust against target movement as no re-registration is needed. Angulated insertion capability in a compact form comparable to a manual template can provide greater access to targets with less restriction.

Transperineal electromagnetically tracked MR/US fusion-guided prostate biopsy is safe and efficacious for the detection of clinically significant prostate cancer
P. Shukla¹, H. Anastos², J. Winoker², M. Carrick², C. Knauer³, B. Taouli⁵, S. Lewis⁶, J. Schwartz⁶, A. Rastinehad⁶; ¹Mount Sinai Hospital, The Icahn School of Medicine, New York, NY; ²The Icahn School of Medicine at Mount Sinai, New York, NY; ³Icahn School of Medicine at Mount Sinai, New York, NY; ⁴Icahn School of Medicine at Mount Sinai Hospital, New York, NY; ⁵Nanospectra Biosciences, Inc, Houston, TX; ⁶Icahn School of Medicine at Mount Sinai Department of Urology, New York, NY

Purpose: Transrectal ultrasound-guided prostate biopsy remains the mainstay for the evaluation of men at risk at prostate cancer. Technological advances in image guidance systems allowing for the fusion of magnetic resonance imaging with intraprocedure ultrasound have demonstrated have shown fusion platforms may significantly improve the diagnostic accuracy of prostate biopsy. A transperineal approach to prostate biopsy has recently gained favor due to risk of infection/sepsis associated with the traditional transrectal approach. Herein, we report our experience with the largest known series of electromagnetically (EM) tracked transperineal MR/US fusion-guided prostate biopsy (tPBlx).

Materials: Transperineal MR/US fusion-guided prostate biopsies were performed in 97 men (mean age: 67.0 ± 8.26 years) with suspicious lesions noted on multi-parametric magnetic resonance imaging at our institution between July 2015 – July 2017. A standard 12-core modified Barzell template mapping biopsy was performed at the same time. Data collected included patient demographics, laboratory values, MRI findings, PI-RADS v2 scores, procedure details, histopathologic correlation, complications, and follow-up.

Results: Of 97 patients, only 27.8% of patients had an abnormal digital rectal examination. Median preprocedure PSA was 7.6 mg/dl (range, 1.59 – 29.10). 55/97 (56.7%) of patients had prior biopsies and 32% (18/55) of those patients of patients were under active surveillance. Technical success of MR/US fusion biopsy was achieved in all patients. 1 patient developed a fever post biopsy all cultures were negative to date. All patients received single dose 160 mg IVPB Gentamincin preprocedure. No other procedure related complications (i.e., bleeding/infection) were observed that resulted in hospitalization or emergent of office visits (glavian Grade III). Overall cancer detection rate was 78.4% (76/97). Clinically significant prostate cancer was diagnosed in 66% (64/97) of patients.

Conclusions: Transperineal MR/US fusion biopsy is safe and effective for the detection of clinically significant cancer. There were no cases of sepsis following biopsy, demonstrating the relative safety of the procedure.
3:18 PM  Abstract No. 213

Real-time biopsy system for combined optical spectroscopy and electromagnetic tracking
H. Amalou1, S. Xu2, A. Sajjadi2, P. Heidari2, M. Li3, R. Suh7, U. Mahmood3, B. Wood6, 1National Institutes of Health & UCLA, Bethesda, MD; 2the National Institutes of Health, Bethesda, MD; 3Massachusetts General Hospital, Boston, MA; 4NIH, Bethesda, MD; 5Ronald Reagan UCLA Medical Center, Los Angeles, CA; 6National Institutes of Health, Bethesda, MD

Purpose: To assess feasibility of custom integration of optical spectroscopy and electromagnetic (EM) tracking on one biopsy platform.

Materials: Custom prototype biopsy systems were combined in one biopsy hardware platform, with 2 side-by-side workstations displays. An interventional phantom (CIRS model 071B) was custom retrofitted with cylindrical targets embedded with indocyanine green (ICG) dye. The ICG targets were pre-imaged with CT prior to biopsy, and then targeted with a custom clinical, non-commercial EM tracking system. The targets were approached with the tracked optical/EM needle, and a surgical laser source (B&W TEC INC and Storz) was used to simultaneously interrogate the tissue during insertion in real time. ICG signal was co-displayed with EM position in relation to the preprocedural CT scan. One confirmation CT scan was obtained to confirm position and to measure EM system error using standard Cartesian coordinate geometry.

Results: Hardware from the two enabling technologies were successfully combined on one biopsy needle platform. Optical and EM signals were simultaneously obtained and co-displayed in real time during simulated biopsy of ICG targets in interventional phantoms. ICG signal and needle location were displayed during needle insertion, successfully confirming needle placement in ICG and EM targets with an EM accuracy of 3 mm. EM was used to place the needle roughly near the ICG target, and the optical signal was used to fine-tune and verify precise tip location at optical source.

Conclusions: One custom platform can provide simultaneous optical and EM feedback during biopsy. Since ICG uptake in liver is predictive of neoplasm, this real-time information could theoretically provide the operating team with molecular, functional, and spatially localizing information in real time. More complete software integration is planned, as well as defining where such a system might potentially add clinical value.

3:27 PM  Abstract No. 214

Development and characterization of a photoacoustic guidance system for percutaneous interventions
S. Bhagavatula1, L. Li2, G. Teachey2; 1Brigham and Women’s Hospital, Boston, MA; 2Massachusetts General Hospital, Boston, MA

Purpose: Photoacoustic (PA) imaging is capable of non-ionizing molecular imaging, high resolution visualization of microvascular and metallic needles, and assessment of in vivo oxygenation. However, due to limited light penetration depths, current PA devices with external light illumination are unable to visualize tissues beyond a few centimeters deep. An interventional PA system with light delivery from the tip of a needle could overcome these limitations and allow PA imaging of deeper tissues, particularly during intervention. We aim to develop and evaluate the imaging characteristics of such a system.

Materials: An interventional photoacoustic (PA) system was developed in which near infrared light is emitted from a tunable laser and can be delivered percutaneously from the tip of a 16G needle into tissue via an optical fiber. A linear ultrasound probe (Ultrasonix, L15-4) was configured for simultaneous PA and ultrasound measurement. PA imaging of an intralipid tissue-mimicking phantom, fresh ex vivo swine liver and muscle tissue was performed with percutaneous (“needle tip”) light illumination. PA signals from a wire grid placed within the phantom and tissues were processed to quantify the imaging resolution and extent/volume of tissue that can be imaged surrounding the needle tip.

Results: Our interventional system allowed concurrent real-time photoacoustic (PA) and ultrasound imaging, with PA visualization of a sphere of tissue surrounding the needle tip. The radius of the PA imaging sphere (maximal distance from needle tip) measured 3.9cm, 5.1cm, and 1.8cm in phantom, muscle, and liver tissue respectively. Average lateral resolution was 1.12 mm and was proportional to distance from the ultrasound probe. Average axial resolution was 93um and did not vary with distance from the ultrasound probe or needle tip.

Conclusions: Interventional PA imaging is feasible, can be simultaneously performed with ultrasound, and allows PA visualization of a sizable volume of tissue around the needle tip, even in tissues with high optical absorption such as the liver. Potential applications include real-time molecular targeted biopsy, in vivo tumor oxygenation assessment, and highly targeted vascular interventions.

3:36 PM  Abstract No. 215

Patient-specific needle guidance templates manufactured intraoperatively for image-guided intervention
N. Glossop1, R. Bale2, S. Xu3, W. Pritchard4, J. Karanian4, B. Wood5; 1Queen’s University, Toronto, ON; 2Medical University of Innsbruck, Innsbruck, Austria; 3the National Institutes of Health, Bethesda, MD; 4National Institutes of Health, Bethesda, MD; 5National Institutes of Health, North Bethesda, MD

Purpose: Multifocal or large tumors can be treated effectively using multiple ablation needles, but it is time consuming and difficult to perform accurately without frequent re-scanning or use of navigation systems. A new targeting method was developed using a custom patient-specific needle guide template, fabricated intraoperatively.

Materials: In an IACUC approved study, a 78kg pig was studied under general anesthesia. Steel balls (1.5 mm) were implanted into the liver to serve as targets. Fiducial markers were affixed to the abdomen. A custom 150 × 220 mm plastic frame designed to hold two parallel plates was fixed over the abdomen using a rigid mounting arm. The frame and subject underwent CT scan with breath-hold. The targets, fiducial and frame were identified in the images. A preprocedure needle trajectory plan was created for each
Safety and efficacy of combined liver transarterial embolization and ablation using cone-beam–computed tomography navigation

B. Bassaco1, R. Yamada1, J. Camacho1, C. Hannegan1, M. Anderson1, M. Guimaraes1; 1Medical University of South Carolina, Charleston, SC

Purpose: To assess the safety and efficacy of combined liver transarterial embolization (TAE) and radiofrequency ablation (RFA) during a single session using cone-beam CT (CBCT) navigation.

Materials: 19 cases treated between May 2014 and January 2017 for liver cancer with transarterial embolization and radiofrequency ablation were studied. 12 patients underwent TAE and RFA during two sessions on sequential or non-sequential days under fluoroscopy and CT guidance (Group 1). 7 patients underwent a one-day single session of combined therapy under fluoroscopy and CBCT with real-time needle guidance (Group 2). Tumor size, total procedure time (PT), patient effective dose (ED), number and purpose of CBCT and CT were examined. Immediate technical success and procedure time (PT), patient effective dose (ED), number and purpose

Results: Mean tumor size was comparable in both groups (2.5cm [1.0 – 7.3] vs 2.8cm [1.1 – 5.1], p = 0.74). An average of 9.58 CT scans were performed for RFA in Group 1 vs. 5.13 CBCT in Group 2 (p<0.001). Mean PT was shorter in Group 1 (120 vs 190’, p = 0.009); however, median ED was more than two times lower in Group 2 (66.8 vs 28.4 mSv in Group 1, p = 0.07). Technical success was reached in all procedures. Complete responses were comparable between groups (67% vs 71%, p = 1). No major complications were observed; one death occurred in Group 1 before follow-up from unrelated causes.

Conclusions: CBCT navigation for TAE and RFA during single session is safe and effective for combined directed liver therapy in patients with hepatic cancer.

Table 1. Results

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure length (min)</td>
<td>120 (85-190)</td>
<td>190 (120-270)</td>
<td>0.009</td>
</tr>
<tr>
<td>Effective dose (mSv)</td>
<td>66.8 (56.85-168.5)</td>
<td>28.4 (13.9-101.4)</td>
<td>0.07</td>
</tr>
<tr>
<td>Number of CT/ CBCT for RFA</td>
<td>9.58 (6-16)</td>
<td>5.13 (3-7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Planning purposes</td>
<td>1.42 (1-3)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Probe positioning</td>
<td>6.75 (2-13)</td>
<td>3.13 (1-5)</td>
<td></td>
</tr>
<tr>
<td>Technical success</td>
<td>1.17 (1-2)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Number of probes</td>
<td>1.75 (1-3)</td>
<td>2.4 (1-3)</td>
<td>0.08</td>
</tr>
<tr>
<td>Ablation time (min)</td>
<td>18 (10-20)</td>
<td>16.5 (10-20)</td>
<td></td>
</tr>
<tr>
<td>Complete response</td>
<td>67%</td>
<td>71%</td>
<td>1</td>
</tr>
<tr>
<td>Partial</td>
<td>8</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Progressive disease</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Technical success</td>
<td>100%</td>
<td>100%</td>
<td>1</td>
</tr>
</tbody>
</table>

Results are presented as mean or median (effective dose) with ranges.

Intra-arterial and intravenous contrast-enhanced ultrasonography for guidance of prostate artery embolization: an initial experience

E. Nzekwu1, A. Mirakhur2, A. Lee3, D. Bakshi4; 1University of Calgary, Calgary, AB; 2UCLA Radiological Sciences, Los Angeles, CA; 3Cumming School of Medicine, University of Calgary, CALGARY, ALBERTA; 4Japanese Red Cross Musashino Hospital, Tokyo, Japan

Purpose: Prostate artery embolization (PAE) is fast gaining ground as a safe and effective non-surgical technique for the treatment of benign prostatic hyperplasia (BPH). Technical/procedural success requires mapping of the prostatic arterial supply, identification of prostatic parenchymal enhancement, avoidance of nontarget embolization and confirmation of an embolization endpoint, infrequently accomplished using digital subtraction angiographic techniques alone. Contrast-enhanced ultrasound (CEUS), an imaging technique, which utilizes the injection of microbubble contrast agents to demonstrate tissue perfusion, lacks the nephrotoxicity and ionizing radiation exposure associated with cone-beam computed tomography (CBCT), thus serving as an attractive adjunct for intraprocedural guidance in PAE.

Materials: From January 2014 to March 2017, a total of 8 patients (mean age 70.4 years, range, 50-92) underwent elective prostate artery embolization for BPH with CEUS guidance. Mean preprocedural prostate size was 159 cc (range, 50-224 cc) with average BMI of 27.2 kg/m² (range, 24.3-30.2). IA and IV CEUS was performed using the Definity (Lantheus Medical Imaging,
North Billerica, MA) microbubble agent. Two of 8 cases used both CBCT and CEUS during PAE to evaluate technical success.

Results: All eight cases achieved technical success with an average PAE procedure time of 233 minutes and total fluoroscopy time of 39 minutes. A total of 20 arteries were studied with IAA CEUS of which 15 arteries demonstrated appropriate prostatic perfusion and 5 demonstrated extraprostatic perfusion. Pre-embolization IAA CEUS confirmed appropriate catheter placement in all cases, was 100% concordant with preoperative CTA and DSA, and confirmed variant anatomy in 2 of 2 patients. Pre- and postprocedure IV CEUS was performed in 4 of 8 patients. Decreased prostatic parenchymal enhancement was noted in all 4 patients post embolization.

Conclusions: IAA/IV CEUS-guided PAE is safe, feasible and potentially useful in selected cases of PAE, in which identification of prostatic feeders cannot be safely accomplished on an angiographic basis alone.

4:03 PM Abstract No. 218

Ultrasound to ultrasound fusion imaging with contrast-enhanced ultrasound during microwave ablation: feasibility study in a perfused porcine liver model

W. Monsky1, M. Averkiou2; 1University of Washington Medical Center, Seattle, WA; 2University of Washington, Seattle, WA

Purpose: The purpose of the study is to test the feasibility of fusion of different phases of enhancement of intraprocedural contrast-enhanced ultrasound (CEUS) with real-time B mode ultrasound during microwave ablation in a machine-perfused porcine liver. Materials: Twelve, 4 cm (100 watt/5 minutes), microwave ablations were performed in four explanted perfused porcine livers, using the GE Logiq E9 with VNav platform, and the C 1-6 probe, enabling CEUS-Ultrasound fusion for guidance. Microbubbles were injected into the arterial and portal vasculature in the perfused liver to display the macro- and micro-circulation with CEUS. A 7 cm sweep across the liver produced a volume set captured in the arterial phase (n = 6) or portal venous phase (n = 6) of contrast enhancement. This volumetric data set was then fused with the active real-time ultrasound image. A spherical marker circumscribing the region, determined to represent the “tumor” was placed. A portion of the encircled “tumor” volume is intentionally not ablated. Following ablation, a second bolus of ultrasound contrast is administered demonstrating continued perfusion of this region in the arterial phase. This volume is fused with real-time ultrasound to ablate this remaining enhanced area. Technical success was defined as the ability to fuse a volumetric image from one phase of the enhanced ultrasound or subsequent post-ablation CEUS with the active live ultrasound as well as the ability to localize the non-ablated, perfused area for additional ablation.

Results: 100% technical success was demonstrated. In all 12 ablations a region in the perfused liver was identified as a “target area” for ablation, seen during CEUS, and fused with the active ultrasound imaging to guide antenna placement. In all cases the post ablation CEUS, demonstrating remaining enhancement of the non-ablated region, was again fused with the active ultrasound image to redirect the antenna to this non-ablated tissue.

Conclusions: This fusion image of different phases of CEUS with real-time ultrasound, using fusion/navigation, allows immediate evaluation of tumor perfusion and ablation for guidance with more complete tumor ablation.

4:12 PM Abstract No. 219

Barriers to adoption of fusion and navigation tools for biopsy and ablation

H. Amalou1, S. Xu2, A. Amalou2, M. Li2, R. Suh3, H. Celik2, B. Wood2; 1NIH & UCLA, Bethesda, MD; 2NIH, Bethesda, MD; 3Ronald Reagan UCLA Medical Center, Los Angeles, CA

Purpose: To describe the different clinical systems for needle navigation and fusion image guidance for needle biopsy and ablation, and to better understand barriers to adoption.

Materials: The different methodologies are described for guiding needle-based biopsy and ablation. The basic principles and differentiating mechanistic features are reviewed, as well as the workflow and clinical indications. Selected representative clinical cases are presented to demonstrate principles and barriers to adoption, such as setup processes, learning curves, complex interface buttons and sequence, cost, and workflow impact. TRUS + MRI fusion-guided prostate biopsy is used as an example to show these principles in fusion biopsy. Costs for in-MRI vs out-of-MRI biopsy are compared.

Results: Biopsy and ablation may benefit from facilitated needle navigation or multi-parametric guidance and real-time feedback. The ability to spatially combine morphometric (or anatomic) with functional (or metabolic) information may enable clinical procedures that would otherwise not be possible. Procedure time, patient throughput, equipment ergonomics, cost, and risk may be facilitated by familiarity with common barriers to adoption. Training tools to reduce learning curves include training videos, slides and bulky hardware setup flow charts. Registration hardware and techniques also differ in underlying mechanisms. These include: electromagnetic tracking, optical tracking, mechanical position sensing, stereotactics or robotics, image-based registration, and camera-on-ultrasound. Both PET and MRI data can be imported to the patient, instead of performing the procedure inside the PET or MRI environment, which can reduce cost. TRUS + MRI fusion-guided prostate biopsy hardware and software approaches demonstrate representative paradigms that differ in terms of underlying mechanisms, rationale, goals, cost, ease of use, and impact upon workflow.

Conclusions: Many different registration and fusion systems and navigation techniques are useful for specific biopsy and ablation clinical scenarios, with variable indications, cost, ease of use, and impact on workflow. Better understanding of barriers to adoption may help realize theoretical benefits.

4:21 PM Abstract No. 220

EZ-Access, a novel 3D printed groin puncture device: no imaging needed!

R. Oklu1, Y. Pershad1, A. Witting1, P. Hangge1, H. Albadawi1; 1Mayo Clinic Arizona, Phoenix, AZ

Purpose: Exsanguination is the leading cause of death after vascular trauma. Resuscitative endovascular balloon occlusion of the aorta (REBOA) can control torso hemorrhage. However, adoption of this approach specifically by the military has been limited by challenges in achieving femoral artery access in austere combat environments. To address this need, we developed a novel 3D printed minimally invasive device, termed EZ-Access, to enable successful vascular access without the need for ultrasound guidance or specialized training for use in the field by first responders.
Materials: EZ-Access was modeled using SolidWorks and 3D printed with a methacrylated resin using FormLabs2 printer. The device measured 14 × 2 × 1 cm with two concave thumb rests on either side of a central plate containing 6 equidistant holes spaced at 0.8 cm. The holes were fitted with a variable number of 21-gauge 7 cm percutaneous entry needles followed by extensive testing. Multiple trials involved IR staff, residents, college and high school students to test success of accurate access of femoral artery using SimuLab models (Seattle, WA). Trial 1 consisted of 3 needles in alternating holes (n = 40). Trial 2 used 6 sequentially placed needles (n = 42). The needles within the device were inserted without ultrasound (US) guidance, two fingerbreadths lateral to the pubic symphysis. The device was angled along the groin crease and the needles entered the skin at 45 degrees. After each puncture, US was used to confirm vessel entry. A control trial was also performed using standard single-entry access needle (n = 5) by staff IR. Statistical analysis performed using Prism software (P = 0.05).

Results: The control trial demonstrated vessel entry rate of 20%. Using 3 alternating needles, successful vessel entry increased to 40% (P = 0.396). With 6 sequential needles, vessel entry success significantly increased to 100% (P < 0.001) regardless of operator experience.

Conclusions: EZ-Access has demonstrated overwhelming success in obtaining consistent percutaneous vascular access in a simulated clinical scenario independent of the operator’s experience without the need for imaging guidance. The device has promising applications in prehospital resuscitation.

### Scientific Session 23

**Venous: Pulmonary Embolism**

Tuesday, March 20, 2018 3:00 PM–4:30 PM  
Room: 404A

3:00 PM Abstract No. 221

**Optimum duration and dose of r-tPA with the acoustic pulse thrombolysis procedure for intermediate-risk (submassive) pulmonary embolism: OPTALYSE PE**

K. Sterling1, N. Jones2, G. Piazza3, S. Goldhaber3, V. Tapson3, 1Inova Alexandria Hospital, Alexandria, VA; 2Mount Carmel East Hospital, Columbus, OH; 3Brigham & Women’s Hospital, Boston, MA; 4Cedars-Sinai Medical Center, Los Angeles, CA

**Purpose:** To explore optimal duration of ultrasound-facilitated, catheter-directed thrombolysis (USCDT) and dose of tPA in patients with submassive pulmonary embolism (PE) randomized to one of four regimens.

**Materials:** Subjects had acute (< 14 days) proximal PE in at least one main or proximal lobar pulmonary artery and a right to left ventricular end-diastolic diameter ratio (RV/LV) ≥ 0.9 on computed tomographic angiography (CTA). Subjects received USCDT with tPA per randomization to one of four treatments (2 hours/8 mg, 4 hours/8 mg, 6 hours/12 mg and 6 hours/24 mg). Primary efficacy endpoint was reduction of RV/LV by greater than 0.2 on CTA 48 hours after starting treatment. Primary safety endpoint was major bleeding within 72 h after initiating treatment. Secondary efficacy endpoints included change in thrombus burden and echocardiographic parameters. Secondary safety endpoints included recurrent symptomatic PE at 30 days.

**Results:** Eighty-three subjects were treated with USCDT bilaterally per randomized dose/duration. All four treatment groups showed significant reductions in the primary efficacy endpoint of reduction in RV/LV 48 hours after starting treatment (Table). Major bleeding occurred in 2 patients (2.4%). There was dose-related significant decrease in thrombus burden in all four treatment groups. There was significant reduction in RV/LV and TAPSE echocardiographic measurements in all treatment groups at 48 hours post procedure. One patient experienced recurrent PE.

**Conclusions:** Lower dose and duration USCDT minimizes the risk of major bleeding while improving measures of RV function. These findings have important implications for shortening procedure time, minimizing tPA exposure, and increasing cost effectiveness.

<table>
<thead>
<tr>
<th>USCDT (h); Total TPA (mg)</th>
<th>N</th>
<th>μ RV/LV Δ CTA (%)</th>
<th>1-Sided P Value Compared with 0.20</th>
<th>MMS Δ;</th>
<th>2-Sided P Value</th>
<th>μ RV/LV Δ Echo (48h); 2-Sided P Value</th>
<th>Major Bleeding Patients (%); N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2; 8</td>
<td>21 -0.46 (27); 0.0030</td>
<td>0.0170</td>
<td>-0.22 ± 0.23; 0 (0); 22</td>
<td>0.0003</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4; 8</td>
<td>21 -0.40 (25); 0.0014</td>
<td>0.0005</td>
<td>-0.25 ± 0.20; 0 (0); 21</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6; 12</td>
<td>24 -0.44 (27); 0.0006</td>
<td>-12%; 0.0001</td>
<td>-0.12 ± 0.23; 0 (0); 24</td>
<td>0.0004</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6; 24</td>
<td>16 -0.52 (27); 0.0145</td>
<td>-22%; 0.0031</td>
<td>-0.32 ± 0.33; 2 (12.5); 16</td>
<td>0.0006</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FEATURED ABSTRACT**

**Relationship of hospital volume on length of stay in patients diagnosed with pulmonary embolism**

M. Finkelstein1, D. Kestenbaum2, E. Kim3, F. Nowakowski3, R. Patel3, V. Bishay4, M. Ranade2, A. Fischman5, R. Lookstein2; 1Icahn School of Medicine at Mount Sinai Hospital, New York City, NY; 2Mount Sinai Hospital, New York, NY; 3Mount Sinai Medical Center, New York, NY; 4Icahn School of Medicine at Mount Sinai Hospital, New York, NY; 5Icahn School of Medicine at Mount Sinai, New York, NY
Catheter-directed thrombolysis for acute pulmonary embolism in 132 patients: a single-center experience

A. Graif1, C. Chedrawy2, A. Vance3, G. Kimbiris4, C. Grilli5, D. Agriantonis6, D. Leung2; 1Christiana Care Health System, Wilmington, DE; 2N/A, Greenville, DE; 3Christiana Care Health System, Newark, DE; 4N/A, Greenville, DE; 5Christiana Care, Wilmington, DE; 6N/A, Newark, DE

Purpose: To evaluate the effectiveness and safety profile of catheter-directed thrombolysis (CDT) for acute massive and submassive pulmonary embolism (PE).

Materials: A retrospective review of 132 consecutive cases (age: 57 ± 15 years, 72 males) of CDT for acute massive (n = 23) and submassive (n = 109) PE between 2009 and 2017 was performed. All patients received full dose anticoagulation before and during thrombolysis with either enoxaparin (n = 37) or heparin (n = 95). Thrombolytic therapy was delivered via multi-sidehole infusion catheters, with or without ultrasound acceleration, or a combination of the two. Primary endpoints included change in invasive pulmonary artery pressure (PAP), change in angiographic thrombus burden (Miller score), hemorrhagic complications (according to GUSTO) and 30-day readmission rate. Secondary endpoints included demographics, duration of thrombolytic therapy, tissue plasminogen activator (tPA) dose infused, duration of intensive care unit (ICU) stay and hospital length of stay after the procedure.

Results: Mean PAP improved from 28.9 ± 8 mm Hg to 17.4 ± 11.1 (p < .001) while the Miller score improved from 19.2 ± 5.1 to 7.4 ± 3.9 (p < .001). There were 6 mild (4.5%), 5 moderate (3.8%) and 1 severe (0.8%) hemorrhagic complications, none of which were intracranial. The mortality rate during admission was 9.1% for the entire cohort, with 4.6% (n = 5) in the submassive group and 30.4% (n = 7) in the massive group (p < .001). The 30-day readmission rate was 5.2% for the surviving patients. The average infusion duration was 26.5 ± 13.1 hours over 2.3 ± 0.7 follow-up visits to the angiography lab, during which a mean of 27.9 ± 16.4 mg of tPA was infused. After the initiation of CDT, the mean ICU stay was 2.75 ± 4.6 days, while the mean hospital length of stay was 6.6 ± 8.3 days.

Conclusions: Catheter-directed thrombolysis for acute PE is effective at reducing PAP and thrombus burden, and is associated with short ICU and hospital length of stay. Full dose anti-coagulation during CDT did not increase the hemorrhagic complication rates.
obstructive index (60.4 vs. 47.0%, p < 0.01) after mechanical thrombectomy. There were no procedural/periprocedural complications. All patients were discharged in stable condition at a mean of 6.7 ± 2.5 days (range, 4-11 days) following intervention. Follow-up was available for 5 out of 6 patients at a mean of 246 ± 145 days (range, 42-196 days). Four out of five patients (80%) were asymptomatic at last known follow-up with return to baseline functional status from prior to acute pulmonary embolism.

Conclusions: Continuous aspiration mechanical thrombectomy is a feasible and promising technique for management of submassive PE to decrease thrombus burden and reduce right heart strain.

3:36 PM Abstract No. 225

The effect of catheter-directed thrombolysis for acute pulmonary embolism on serum fibrinogen levels
A. Graif1, C. Chedrawy2, A. Vance3, S. Putnam4, G. Kimbiris5, K. Lie6, C. Grilli7, D. Leung2; 1Christiana Care Health System, Wilmington, DE; 2Christiana Care Health System, Newark, DE; 3Christiana Care Health System, Philadelphia, PA; 4Christiana Hospital, Newark, DE; 5N/A, Greenville, DE; 6N/A, Landenberg, PA; 7N/A, Wilmington, DE

Purpose: To evaluate the effect on serum fibrinogen levels of catheter-directed thrombolysis (CDT) for treatment of acute massive or submassive pulmonary embolism (PE).

Materials: A retrospective review in a single health care system between 2009 and 2017 was performed to identify patients who underwent CDT utilizing t-PA for acute massive or submassive PE with and without ultrasound-accelerated thrombolysis (USAT). Full dose anticoagulation was administered before and during CDT with either heparin or enoxaparin. Endpoints included serum fibrinogen levels obtained approximately every 6 hours during treatment, infusion duration, t-PA dose and hemorrhagic complications (GUSTO).

Results: 121 cases of CDT for acute PE were reviewed (Age: 57.5 ± 14.1, 69 males, 17 massive PE) including 39 cases in which USAT was utilized exclusively, and 35 patients who received enoxaparin. The mean initial fibrinogen level was 372.2 ± 233.3 mg/dl (range, 65-884), while the mean final fibrinogen level was 351.8 ± 124.9 mg/dl (56-788), with a statistically significant (p = 0.01) mean reduction of 20.4 ± 78.8 mg/dl (5.5%). Mean infusion duration was 27.4 ± 12.9 hours (6-67), and the mean t-PA dose infused was 29.2 ± 16.1 mg (4.8-114). When comparing CDT to conventional CDT, and enoxaparin to heparin, there was no significant difference in initial fibrinogen level (p = .34 and p = .9 respectively) or fibrinogen reduction (p = .94 and p = 42 respectively) between the groups. There were 9 hemorrhagic complications (6 GUSTO mild, 2 moderate and 1 severe) in 9 patients with a mean age of 63.9 ± 15.5 years. Initial and final fibrinogen levels in those 9 patients were 335.7 ± 218.9 mg/dl and 10.3 ± 71.5 mg/dl (3.1%), respectively, with a non-significant (p = .77) mean reduction of 10.3 ± 71.5 mg/dl (3.1%).

Conclusions: In this cohort, CDT for acute PE significantly reduced serum fibrinogen but the reduction did not correlate clinically with hemorrhagic complications. The use of USAT versus conventional CDT or the choice of heparin versus enoxaparin did not have an effect on fibrinogen levels.

3:45 PM Abstract No. 226

Clinical presentation of submassive pulmonary embolism is associated with baseline pulmonary artery pressure and response to catheter-directed thrombolysis
D. Patel1, Y. Huang1, R. Gaba1, L. Liu2, R. Lokken1; 1University of Illinois Health, Chicago, IL; 2Center for Clinical and Translational Science, University of Illinois at Chicago, Chicago, IL

Purpose: To determine the association between clinical presentation and baseline pulmonary artery pressure (PAP) and response to catheter-directed thrombolysis (CDT) in patients with submassive pulmonary embolism (PE).

Materials: Records of 46 consecutive patients (25 men, 21 women, mean age 55 ± 14 years) who underwent CDT for submassive PE between September 2009 and February 2017 were retrospectively reviewed. PAP was measured at baseline and daily until CDT termination. Effects of tissue plasminogen activator (t-PA) dose and CDT duration on PAP were examined with multivariate mixed-effects models; backward selection was used to analyze interactions of comorbidities, symptoms, simplified pulmonary embolism severity index (sPESI), and shock index (SI) with baseline PAP and response to t-PA dose and CDT duration.

Results: Average baseline mean PAP was 28.3 ± 8.5 mm Hg. Mean t-PA dose rate was 0.7 ± 0.3 mg/h for a total 43.0 ± 30.0 mg over 61.9 ± 28.8 h. Mixed-effects regression models demonstrated a linear decrease in mean PAP of 0.18 mm Hg/h (β = -0.15 (SE = 0.03), p 1 (p = 0.03), 3.3 mm Hg higher in patients with sPESI > 0 (27.0, p = 0.01), and 5.4 mm Hg higher in patients with history of systemic hypertension (p = 0.003). Mean PAP was 8.6 mm Hg lower in patients with active malignancy (p = 0.002) and 5.8 mm Hg lower in patients with active tobacco use (p = 0.01). Patients with SI > 1 demonstrated a steeper decline in mean PAP over time during CDT (β = -0.08 (SE = 0.03), p = 0.03).

Conclusions: Baseline clinical factors such as elevated SI, sPESI, and history of systemic hypertension are associated with higher baseline PAP in patients with submassive PE. Patients with elevated SI demonstrated an increased rate of PAP reduction during CDT.

3:54 PM Abstract No. 227

Catheter-directed management for pulmonary embolism versus medical management: the new interventional radiology STEMI?
C. Hennemeyer1, G. Woodhead1, C. Moffet1; 1University of Arizona, Tucson, AZ

Purpose: To use retrospective analysis of right heart strain pre- and postcatheter-directed intervention in patients with massive and submassive pulmonary embolus (PE), then compare outcomes to matched controls. Newer tools for catheter intervention now allow for combination mechanical and chemical lytic therapy for massive and submassive PE. The authors hypothesize that when used in combination, clot aspiration and directed lytics may improve measures of right heart strain, providing a foundation for altering the course of a disease.
Materials: The retrospective IRB approved study investigates the treatment group of 25 patients who underwent catheter based therapy consisting of single, or combination mechanical and chemical lytic therapy. The controls were patients with PE matched for similar severity of disease RV/LV ratio and other risk other factors. Controls were given medical management including systemic anticoagulation only. All available pre- and postprocedural cardiac imaging including CTA, and Echo were used to assess RV strain. Strain was measured using am established comparison of RV to LV diameters.

Results: Over a one year, 25+ patients at a single institution underwent catheter based therapy. Two devices had been used, either alone or in combination; Penumbra’s Indigo, and BTG’s Ekos were used. A roughly equal total dose of lytics (TPA) was given in both groups averaging 28 mg administered either single dose or 22hr infusion. Average preprocedure diagnosis was 1 day, and post procedure follow-up 1.8 days. RV/LV ratios between the two groups suggested a significant improvement right ventricular strain as measured by a change in RV/LV ratio.

Conclusions: Catheter based therapy showed improvement in outcome measure vs medical management alone comparing right heart strain. A combination of catheter based tools including mechanical aspiration of clot, and directed lytics may be used in intermediate and high-risk PE patients safely. If widely available, catheter based therapy stands also to change the practices of Interventional physician’s approach analogously to other cardiac emergencies such as STEMI creating the expectation expectation to provide emergent or semi-emergent responses.

4:03 PM Abstract No. 228

Ultrasound-assisted catheter-directed thrombolysis for submassive pulmonary embolism: efficacy in relief of right heart strain
J. Manov1, F. Contreras2, M. Langston2, M. Doshi2, P. Mohan3; 1University of Miami School of Medicine, Miami, FL; 2University of Miami, Miami, FL; 3University of Miami Miller School of Medicine, Miami, FL; 4Universiy of Miami Miller School of Medicine, Miami, FL

Purpose: To determine the outcomes, safety profile, and efficacy of ultrasound-assisted catheter-directed thrombolysis for pulmonary embolism with right heart strain.

Materials: The charts of 30 consecutive patients who underwent CDT as treatment for pulmonary embolism were reviewed. Risk factors for bleeding were noted. Indicators of right heart strain on computed tomography and echocardiogram, as well as degree of pulmonary vascular obstruction, were recorded before and after CDT. Thirty-day mortality and occurrence of bleeding events were recorded.

Results: Right ventricular systolic pressure decreased from an average of 53.1 mm Hg to 38.5 mm Hg (p = 0.001) and average Qanadli index of pulmonary vascular obstruction decreased from 49 to 13 (p = 0.016) from 49 to 34 (p = 0.001) after CDT. The average ratio of RV/LV diameter decreased from 1.48 to 1.17 (p = 0.001). The number of patients with RV hypokinesis decreased significantly (p = 0.001) from 19 (95% of those with available data) to 12 (60%). The number of patients with RV dilation decreased significantly (p = 0.001) from 19 (95% of those with available data) to 13 (65%).

Nine (30%) patients had three or more minor contraindications to thrombolysis and fourteen (47%) had major surgery in the month prior to CDT. No patients experienced major or moderate bleeding attributed to CDT.

Conclusions: In our experience CDT proved effective in the rapid alleviation of right heart strain with minimal bleeding risk. Right heart strain is associated with increased mortality and long-term morbidity in pulmonary embolism and CDT may allow for a safe means of improving outcomes in submassive pulmonary embolism. We found CDT to be a safe alternative to systemic thrombolysis in patients with risk factors for bleeding such as prior surgery.

4:12 PM Abstract No. 229

The thromboaspiration with INDIGO system reduces the time and dose of fibrinolysis and improves the results in massive pulmonary embolism in comparison with catheter fragmentation (previous cohort study)
J. Guirola Ortiz1, C. Serrano Casorran2, D. Jimenez Castro3, M. Sanchez Ballestin2, A. Figueroed Cacacho4, W. Kuo5, M. De Gregorio6; 1Lozano Blesa University Hospital, Zaragoza, Zaragoza; 2GITMI. Minimally invasive techniques research group., Zaragoza, Zaragoza; 3Hospital Ramón y Cajal, Madrid (España), Madrid, Madrid; 4Hospital Universitario Miguel Servet. Zaragoza. Spain, Zaragoza, Zaragoza; 5Stanford University Medical Center, Stanford, CA; 6Universidad de Zaragoza. Spain, Zaragoza, Spain

Purpose: Determine if thromboaspiration with indigo system improves short- and medium-term outcomes compared with interventional treatment of choice for pulmonary embolism (PE) (mechanical thrombolysis + catheter-directed thrombolytic therapy).

Materials: From Apr-2016 to Aug-2017, 43 patients diagnosed massive PE and a comparative with previous study of 111 patients with massive PE. In the first cohort all patients were treated with thromboaspiration + catheter-directed thrombolytic therapy (TAs) and the other cohort were treated with conventionally according to our protocol: thrombolysis + catheter fragmentation (MFT). There were no significant differences in age, sex and the angiographic pulmonary index (Miller index). Pulmonary pressures after fibrinolysis and one month later were compared. The total dose and the total time of fibrinolysis were also compared in both groups.

Results: Postoperative mean pulmonary arterial pressure (PAPm) was 34.06 ± 5.81 mm Hg TAs and 39.46 ± 6.39 mm Hg MFT,
without showing significant differences in both groups regarding the 24 hours and after 1-month angiographic control. There were significant differences in the total dose administered of urokinase (UK) (1.38 ± 0.25 IU of UK TAs MFT vs 2.82 ± 0.89 million IU of UK MFT) and the total time of UK perfusion (13.05 ± 1.70 hours TAs vs. 21.69 ± 11.92 hours MFT). Four patients (9.3%) died in the follow-up in the cohort TAs with only 1 (2.3%) related to PE vs. 7 patients (6.3%) with only 4 (3.6%) related to PE or complications of endovascular treatment MFT.

Conclusions: Thromboaspiration improves the results of conventional mechanical fragmentation and catheter-directed thrombolysis (UACDT). Thromboaspiration improves the results of conventional mechanical fragmentation and catheter-directed thrombolysis (UACDT).
Factors associated with the secondary functional access patency after percutaneous transluminal angioplasty of the early failing or immature hemodialysis arteriovenous fistula

W. Higashiu1, H. Takara1; 1Okinawa Prefectural Chubu Hospital, Uruma, Okinawa

Purpose: To evaluate the efficacy of percutaneous transluminal angioplasty (PTA) for early failing hemodialysis arteriovenous fistula (AVF) and predictive factors for the secondary functional patency.

Materials: A review of the endovascular registry database for our department showed 61 patients with the early failure after the surgically created AVF underwent endovascular intervention between July 2011 and October 2016. The patients were characterized by being 48% male with median age of 68 years. The median of the duration of time from AVF creation to first intervention was 5.6 weeks (range, 1-12 weeks). Median duration of follow-up was 14 months. Items concerning technical success rate, primary and secondary functional patency, factors associated with secondary functional patency were analyzed.

Results: Angiography revealed 38 stenoses and 23 occlusions. Median length of lesions was 4.5 cm (range; 1-25 cm). Technical success was achieved in 55 (90%) of 61 patients. The primary and secondary functional patency rates were 42% and 65% at 12 months, respectively. Univariate analysis indicated that lesion length (p = 0.009) and lesions including juxta-AVF (p = 0.057) should be considered as a risk factor for secondary functional patency. Multivariate analysis using Cox proportional hazards regression model indicated lesion length (hazard ratio; 1.15, P = 0.001) and lesion including juxta-AVF (hazard ratio; 6.30, P = 0.008) as a risk factor associated with secondary functional patency. ROC curve analysis indicated lesion length ≥9 cm as a cutoff value of a risk factor for secondary functional patency. The secondary functional patency at 12 months was 86% for patients with no risk factor (n = 23), 65% for patients with 1 risk factor (n = 33), and 0% for patients with 2 risk factors (n = 5). There was significant difference in secondary functional patency rate among these groups (P = 0.001).

Conclusions: The juxta-AVF lesion and length of lesions are the risk factors for the secondary functional patency. Secondary functional patency rate at 12 months is acceptable in patients without risk factors.

Severe arm swelling in hemodialysis patients with an arteriovenous access and ipsilateral central vein stenosis: comparison of stent deployment versus conversion to a HeRO graft

B. Cline1, A. Griffin1, S. Gage1, E. Dillavou1, J. Lawson1, C. Kim1; 1Duke University Medical Center, Durham, NC

Purpose: In ESRD patients with indwelling arteriovenous (AV) fistulas or grafts, central venous stenosis can result in massive arm swelling. For angioplasty-resistant lesions, treatment options include stent deployment, conversion to HeRO graft, and access ligation. While stent deployment is the least invasive option, stents have the potential to limit access options on the ipsilateral or contralateral side. The purpose of this study was to compare clinical outcomes in patients with severe arm swelling due to a central vein stenosis ipsilateral to AV fistula or graft treated with stent deployment versus access conversion to a HeRO graft.

Materials: This retrospective study was performed on 52 patients (19 males, 32 females, mean age 56.6) with severe arm swelling ipsilateral to an AV access and a central vein stenosis. Of these, 29 patients underwent central venous stent deployment and 23 underwent placement of a HeRO graft with anastomosis directly to the existing graft or fistula. Symptomatic improvement in arm swelling, and primary and secondary access patency were ascertained from medical records. Categorical and continuous variables were compared with the chi square and t-test respectively. Patency rates were calculated with the Kaplan-Meier technique and compared with the log rank test.

Results: The two groups were not significantly different with regard to gender (p = 0.78), age (p = 0.61), side of AV access (p = 1.0), fistula versus graft (p = 0.56), or age of access (p = 0.45). Improvement in swelling was found in 86% and 95% after stent deployment or HeRO conversion within 1 month, respectively (p = 0.55). The median primary patency was significantly longer for HeRO conversions than stent deployments (18.9 vs 5.4 months, p < 0.001). HeRO conversions also resulted in longer secondary patency (105.2 vs 29.4 months, p = 0.005). The mean number of interventions to maintain secondary patency was 2.7 per 1000 access days for HeRO conversions and 6.3 per 1000 access days for stent deployments.

Conclusions: In patients with severe arm swelling due to a central venous stenosis ipsilateral to an AV access, conversion of the access to a HeRO graft resulted in significantly longer primary and secondary patency rates than stent deployment.

Tunneled femoral dialysis catheters and factors effecting its failure: a single-institute experience

M. Mesick1, P. Kavali2, S. Kim3, N. Mani4; 1Mallinckrodt Institute of Radiology, St. Louis, MO; 2Mallinckrodt Institute of Radiology, St. Louis, MO; 3Mallinckrodt Institute of Radiology Washington University in St. Louis, St. Louis, MO; 4Mallinckrodt Institute of Radiology, Chesterfield, MO

Purpose: To assess whether factors such as the catheter placement side, catheter length, catheter tip position, and inpatient/ outpatient status, correlate with malfunctioning of tunneled femoral dialysis catheters.

Materials: Patients were selected from our Institution’s radiology information system after getting IRB approval. A total of 63 patients had 97 tunneled femoral dialysis catheters placed between July 2010 and January 2017. The catheter length, side of catheter placement in groin, catheter tip position as well as inpatient or outpatient status at time of placement were the factors evaluated to assess if any of them contributed directly to catheter
malfunctioning. Appropriate statistical analysis was done with a p value of 0.05 as cutoff.

**Results:** The average age of the patients was 56.4 years and 50% were male. 60% of catheters were placed on inpatients. 74% of the patients had the catheter in right common femoral vein and 26% in left common femoral vein. Catheter lengths were: 55 cm (53%), 40 cm (38%), and less than 40 cm (9%). Catheter tip positions were in the right atrium 15%, inferior caval-trial junction 15%, and inferior vena cava 70%. 47% of catheters required an intervention (either exchange or removal) prior to the patient either having regained normal renal function or having a established permanent dialysis access. The average time to first intervention on these patients was 82.4 days (range, 1-328 days). 53% of patients were treated successfully, defined as either having regained renal function, established permanent HD access, or died with their catheters in place.

The average age of these catheters was 116 days.

**Conclusions:** In our institutional experience, femoral tunneled dialysis catheter failure is not correlated with factors easily controlled by the operator such as side of catheter placement, catheter length, or catheter tip position. Neither is the malfunctioning correlated with inpatient status. However, in general, it can be ascertained that the femoral dialysis catheters do not function well in the long term. Limitations of our study include the relatively large percentage of patients lost to follow-up (24%) and its retrospective nature.

### Table

<table>
<thead>
<tr>
<th>Tip position</th>
<th>Successful Failure</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left side</td>
<td>18% (7/38) 33% (12/36)</td>
<td>0.18</td>
</tr>
<tr>
<td>Length: 55 cm</td>
<td>(51%) 17/33 61% (16/26)</td>
<td>0.18</td>
</tr>
<tr>
<td>Length: 40 cm</td>
<td>(48%) 16/33 27% (7/26)</td>
<td>0.18</td>
</tr>
<tr>
<td>Length: &lt;40 cm</td>
<td>3% (1/33) 12% (3/26)</td>
<td>0.18</td>
</tr>
<tr>
<td>Tip position: RA</td>
<td>24% (9/38) 17% (6/35)</td>
<td>0.72</td>
</tr>
<tr>
<td>Tip position: CA-J</td>
<td>21% (8/38) 20% (7/35)</td>
<td>0.72</td>
</tr>
<tr>
<td>Tip position: IVC</td>
<td>55% (21/38) 63% (22/35)</td>
<td>0.72</td>
</tr>
<tr>
<td>Inpatient</td>
<td>50% (18/36) 66% (24/36)</td>
<td>0.23</td>
</tr>
</tbody>
</table>

**Abstract No. 235**

### The diameter of the artery can predict aneurysm formation after arteriovenous fistula creation

**A. Cahalane**, V. Sahani, Z. Irani, J. Cui; **Massachusetts General Hospital, Boston, MA**

**Purpose:** To determine whether inflow arterial diameter predicts the development of arteriovenous fistula (AVF) aneurysms.

**Materials:** This retrospective study examined patients with aneurysmal AVF dilatation requiring surgical resection/revision between 01/01/2014 and 07/30/2016. Patients’ demographic information, causes of ESRD, location of access, access creation date and surgical data were collected. Fistulogram (FG) images were reviewed and diameter of feeding artery, venous outflow, maximum aneurysmal segment, and length of aneurysmal segment were measured. The location of stenoses identified during FG were recorded.

**Results:** 27 patients were identified, 10 female and 17 male. 21 patients (77.78%) had brachiocephalic AVFs and 6 had radiocephalic AVFs (22.22%). The mean interval between surgical creation of the AVF and access revision due to aneurysm was 1411 ± 955 days. 7 patients did not have venous outflow stenosis on FG. The most common venous outflow lesion was cephalic arch stenosis, which was identified in 64.7% patients. 47% patients had venous outflow stenosis and 23.5% patients had central stenosis. On the first FG, there was a significant correlation between feeding artery diameter and vein diameter (r = 0.51, p = 0.02), the maximum diameter of the aneurysm (r = 0.67, p = 0.03) and the length of the aneurysmal segment (r = 0.92, p = 0.0001). The interval between first recorded FG and surgical revision was 818 ± 819 days. The last FG prior to surgical revision was reviewed. The diameter of the artery in the last FG was strongly correlated with the diameter of the artery in the first fistulogram (p<0.05). Furthermore, length of the aneurysmal segment on the last FG correlated with diameter of the artery in the first FG.

**Conclusions:** Aneurysm formation is a long-term complication of AVF, which normally occurs in AVFs created using the cephalic vein. Cephalic arch stenosis is the most common culprit lesion. The diameter of the feeding artery in the initial FG predicts the severity of the aneurysm at later time points. AVF with relatively larger arterial diameter and cephalic arch stenosis should be monitored for aneurysm formation closely and may need early intervention to prevent aneurysm formation.

**Abstract No. 236**

### Declotting procedures for the treatment of thrombosed vascular access circuits: a parametric meta-analysis of 17 studies including 3000 endovascular procedures

**P. Kitrou**, K. Katsanos, P. Papadimatos; **S. Spiliopoulos**, D. Karnabatidis; **Patras University Hospital Imaging and Interventional Radiology Department, Patras, Greece; 2nd Radiology Department, Interventional Radiology, National and Kapodistrian University, Athens, Greece**

**Purpose:** To evaluate the effectiveness of different types of declotting procedures for the treatment of thrombosed arteriovenous grafts (AVGs) and fistulas (AVFs).

**Materials:** Review of the literature provided 17 studies since 2001. There were 8 retrospective and 9 prospective studies, including 1807 patients, undergoing 3000 procedures in 1067 AVGs and 409 AVFs. Lyse and wait, pulse spray, pharma-mechanical, lysis-assisted balloon thrombectomy, mechanical and thrombo-aspiration declotting procedures were included. Primary outcome measure was postintervention assisted primary patency (PAPP). Secondary outcome measures included independent factors that could influence patency.
Results: In total at 6, 12 and 24 months PAPP was 54.8% (CI: 44.8-67%), 41.6% (CI: 30.4-57%) and 26% (CI: 17-39%) respectively with a median of 11 months. There was a significant difference in PAPP in favor of AVFs compared with AVGs at 24 months [60.2% (CI: 44.82%) vs. 14.8% (CI: 7.4-29.7%), p<0.009] studies were compared at 12 months [NEW: 50.1% (CI: 34.3-73%) vs. OLD: 30.4% (CI: 19.4-47.7%), p<0.01].

Conclusions: Declotting procedures were significantly more effective in AVFs improving their PAPP results over time. None of the main categorical methods described in literature had significantly better results over the other.

4:00 PM Abstract No. 237
Lysis-assisted balloon thrombectomy: a declotting method for the treatment of thrombosed arteriovenous dialysis grafts: results from a retrospective analysis of 241 endovascular procedures
P. Kitrou1, P. Papadimatos1, K. Katsanos1, S. Spiliopoulos2, S. Papadoulas3, E. Papachristou4, D. Karnabatidis5, 1Patras University Hospital Imaging and Interventional Radiology Department, Patras, Greece; 22nd Department of Radiology, Interventional Radiology Division, Attikon University Hospital, Athens, Greece; 3Patras University Hospital, Vascular Surgery Department, Patras, Greece; 4Patras University Hospital, Nephrology Department, Patras, Greece

Purpose: This is a retrospective single-center analysis investigating the results of a percutaneous lysis-assisted balloon (LAB) thrombectomy procedure for the treatment of thrombosed arteriovenous dialysis grafts (AVGs).

Materials: From January 2012 to December 2016 (5 years), 291 declotting procedures were performed for the treatment of thrombosed dialysis arteriovenous fistulas or grafts. Data were available for 129 patients (75 men, 58.1%) with an AVG, undergoing 241 procedures [1.87 procedures/patient (1-10)]. Procedure includes initial lysis with 5 mg recombinant tissue plasminogen activator followed by thrombectomy with a high-pressure balloon for thrombus maceration using “facing sheaths” technique. 61 patients had ≥2 declotting procedures. In 80 cases (80/241; 33.2%) a stent graft (SG) was used for treatment of persistent stenosis. The primary endpoint was clinical success and postintervention assisted primary patency (PAPP). Secondary outcome measures included procedural complications and investigation of independent factors that could influence circuit survival.

Results: Median PAPP was 434 days according to Kaplan Meier survival analysis. Clinical success was 96.26%. In 6 cases (6/241, 2.49%) declotting failed and a catheter was placed. There were 16 minor (16/241, 6.64%) and no major complications. There was no significant difference in circuit survival regardless of SG use (No SG 406 days vs. SG 349 days; p = 0.24). There was a significant difference in favor of the 2nd declotting compared to the 1st in 61 patients (1st: 162 days vs. 2nd: 447 days; p<0.0001).

Conclusions: LAB thrombectomy resulted in high circuit survival rates with increased technical success and minimum complications without the use of thrombectomy devices.

4:10 PM Abstract No. 238
Outcomes of imaging-guided placement versus laparoscopic placement of peritoneal dialysis catheters
A. Abdel Aal1, K. Mahmoud1, S. Moawad1, N. Ertel2, P. Rageeb1, I. Shawali1, A. Mokhtar1, B. Hamed1, A. Almehmi1, 1University of Alabama at Birmingham (UAB), Birmingham, AL

Purpose: A variety of peritoneal dialysis catheter (PDC) placement techniques are available including laparoscopic placement by surgeons, and radiologic placement by interventional radiologists. The aim of this study was to compare the one-year outcomes of both techniques.

Materials: We retrospectively reviewed the medical records of 240 patients who had their first PDC placed between January 2005 and December 2015. We compared the outcomes of the catheters placed using laparoscopic technique (IR group, n = 50) with the catheters placed using laparoscopic technique (LAP group, n = 190). The primary endpoint was complication-free catheter survival at 365 days. Secondary endpoints were complication-free catheter survival at 90 days and overall catheter survival at 365 days.

Results: The study included 240 patients, 134 females (56%), median age was 54.7 years (IQR = 41.3-64.3), and median BMI was 28.3 (IQR = 24.1-34.5). There was no significant difference in the baseline characteristics of both groups. In the IR group, the complication-free catheter survival at 90 and 365 days were 64% and 48%, which was not different when compared to 70.5% (p = 0.37) and 53.4% (p = 0.49) respectively, in the LAP group. Catheter malfunction was significantly higher in the LAP group (30%) compared to the IR group (16%, p = 0.05). Catheter leak was significantly higher in the IR group (10%) compared to the LAP group (3.2%, p = 0.05). There was no statistically significant difference in the overall catheter survival at 365 days between the two groups.

Conclusions: Percutaneous radiologic placement of PDC offers a clinically effective alternative to laparoscopic placement with similar survival rates. The rate of catheter malfunction was higher in the LAP group, while the rate of catheter leak was higher in the IR group.

4:20 PM Abstract No. 239
Outcomes of elective versus urgent-start peritoneal dialysis catheter placement
A. Abdel Aal1, K. Mahmoud1, S. Moawad1, R. Oser1, N. Ertel1, P. Rageeb1, I. Shawali1, A. Mokhtar1, B. Hamed1, M. Massoud1, A. Almehmi1, 1University of Alabama at Birmingham (UAB), Birmingham, AL

Purpose: A variety of peritoneal dialysis catheter (PDC) placement techniques are available including laparoscopic placement by surgeons, and radiologic placement by interventional radiologists. The aim of this study was to compare the one-year outcomes of both techniques.

Materials: We retrospectively reviewed the medical records of 240 patients who had their first PDC placed between January 2005 and December 2015. We compared the outcomes of the catheters placed using laparoscopic technique (IR group, n = 50) with the catheters placed using laparoscopic technique (LAP group, n = 190). The primary endpoint was complication-free catheter survival at 365 days. Secondary endpoints were complication-free catheter survival at 90 days and overall catheter survival at 365 days.

Results: The study included 240 patients, 134 females (56%), median age was 54.7 years (IQR = 41.3-64.3), and median BMI was 28.3 (IQR = 24.1-34.5). There was no significant difference in the baseline characteristics of both groups. In the IR group, the complication-free catheter survival at 90 and 365 days were 64% and 48%, which was not different when compared to 70.5% (p = 0.37) and 53.4% (p = 0.49) respectively, in the LAP group. Catheter malfunction was significantly higher in the LAP group (30%) compared to the IR group (16%, p = 0.05). Catheter leak was significantly higher in the IR group (10%) compared to the LAP group (3.2%, p = 0.05). There was no statistically significant difference in the overall catheter survival at 365 days between the two groups.

Conclusions: Percutaneous radiologic placement of PDC offers a clinically effective alternative to laparoscopic placement with similar survival rates. The rate of catheter malfunction was higher in the LAP group, while the rate of catheter leak was higher in the IR group.
Purpose: Laparoscopic and radiologic placement techniques of peritoneal dialysis catheter (PDC) can be used with urgent-start and elective peritoneal dialysis (PD). The objective of this study is to compare the outcomes of elective versus urgent-start use of the PDC regardless of the technique used for placement.

Materials: We retrospectively reviewed the medical records of patients who had their first peritoneal dialysis catheter placed and used between January 2005 and December 2015. The patients were divided into two groups; group A and B were elective and urgent-start PD respectively. The primary endpoint was complication-free catheter survival at 90 and 365 days. Secondary endpoints were catheter survival at 90 and 365 days, median days-to-first complication and median days-to-catheter removal.

Results: The study included 240 patients, 134 females (56%), median age was 54.7 years (IQR = 41.3-64.3), and median BMI was 28.3 (IQR = 24.1-34.5). There were 211 patients in group A. There was no significant difference in the baseline characteristics of both groups. The 90 and 365 days complication-free catheter survival and the overall catheter survival at 365 days were not different between the two groups (69.7%, 52.4% and 51.7% for group A, 65.5%, 51.7% and 33.3% for group B, p = 0.64, 0.94 and 0.07 respectively). Catheter survival at 90 days was significantly higher for group A compared to group B (87% and 70% respectively, p = 0.04). Catheter leak was significantly lower in group A (3.3%) compared to group B (13.8%) (p = 0.03) and occurred more in the radiologic technique compared to the laparoscopic technique (p = 0.05). There was a trend towards higher catheter malfunction in group A (28.4%) compared to group B (17.2%), which was not significant (p = 0.20). The median days until removal were 376 and 197 days respectively which was not significant (p = 0.07).

Conclusions: Apart from catheter leak, there was no significant difference in the complication rate of PDC placed for elective versus urgent-start PD. The 90 day overall catheter survival was significantly better for elective PDC and catheter removals occurred earlier in the urgent-start PDC.

Scientific Session 25
Ablation: Renal

Tuesday, March 20, 2018
3:00 PM–4:30 PM
Room: 405

3:00 PM
Abstract No. 240

Thermal ablation for stage IA renal cell carcinoma: contemporary national variation in clinical management and outcome
J. Uhlig1, N. Kokabi2, H. Kim2; 1University Medical Center Goettingen, Goettingen, Germany; 2Yale School of Medicine, New Haven, CT

Purpose: To investigate US national trends in utilization of thermal ablation for management of T1aN0M0 renal cell carcinoma (RCC) and evaluate associated outcomes.

Materials: Patients treated with thermal ablation or nephrectomy for T1aN0M0 renal cell carcinomas diagnosed between 2004 and 2013 were retrospectively studied using the National Cancer Database (NCDB). Socio-demographic factors were analyzed as potential predictors of RCC treatment. Propensity score models were used to obtain a matched patient cohort with balanced distribution of baseline variables. Unplanned hospital readmission rates within 30 days post treatment, 30 day and 90 day post-operative mortality, and overall survival were analyzed in the matched cohort.

Results: 44,119 patients (88.2%) receiving nephrectomy and 6,044 patients (11.8%) receiving thermal ablation fulfilled the inclusion criteria. Thermal ablation patients were in general older and had relevant comorbidities. Socio-demographic factors associated with increased likelihood of thermal ablation treatment were male gender, white race, insurance by Medicare, receiving therapy at an academic center, residing in a South Atlantic State, and large urban areas with lower median family income (each p < 70 years and during the first post-operative year.

Conclusions: RCC treatment by thermal ablation shows substantial national variation in the US. Thermal ablation appears to be underutilized in vulnerable populations such as patients in rural areas or without comprehensive healthcare coverage. Thermal ablation is well tolerated with low unplanned hospital readmission rates and 30d/90d postoperative mortality.
biopsy was not routinely performed. Introduction of pre-
procedure biopsy prior to intervention for equivocal lesions
resulted in 35% relative reduction of ablation for benign
lesions in the ablation group. Similar intervention was not
performed in the nephrectomy group. Complication rates were
lower in the ablation group (9% vs. 30%, p<0.05). Hospi-
talization was 0.4 ± 0.3 days for ablation and 6.1 ± 8.8 days
(p<0.05) for surgical patients. The mean reduction in eGFR
was 5.9 mL/min and 12.1 mL/min, respectively, in the abla-
tion and nephrectomy groups. Tumor recurrence occurred in
1% and 5% of the ablation and surgical patients, respectively.
Overall survival was similar regardless of type of treatment
received (p = 0.287).

Conclusions: Ablation is a safe alternative to nephrectomy in
the treatment of small renal tumors, with similar long-term outcomes
and significant reduction in duration of hospitalization and
complication rates. Our data supports the routine practice of pre-
procedural biopsy to reduce the rate of intervention for benign
lesions. Study limitations are retrospective data analysis, loss to
follow-up, and limited statistical power.

3:18 PM Abstract No. 242

Long-term follow-up of image-guided thermal
ablation for pathologically proven T1a renal
tumors: radiofrequency ablation or cryoablation
M. Abdelsalam1, S. Sabir2, S. Kusin3, J. Karam3,
S. Matin4, C. Wood5, K. Ahrar2; 1The university of Texas
MD Anderson cancer center, Houston, TX; 2MD
Anderson Cancer Center, Houston, TX; 3The university
of Texas MD Anderson cancer center, Houston, TX;
4MD Anderson, Houston, TX

Purpose: To compare the long-term oncologic outcome (10 years
follow-up) and survival rates of radiofrequency ablation versus
cryoablation for pathologically proven T1a Renal cell carcinoma
(RCC).

Materials: Between January 2005 and June 2017, we studied
patients with newly developed pathologically proven T1a RCC
(< 4 cm). We excluded patients who had ablation within the
last 30 months, those with benign lesions or unknown histol-
ogy, those with syndromes, and those with prior history of or
bilateral RCC. We recorded: Demographics, clinical presenta-
tion, renal tumor size and histology, thermal ablation tech-
nology, complications, Local recurrence, metastases from RCC,
history of another primary cancer, survival/death and cause of
death. Two groups were created: patients with RCC treated
with (A) RFA or (B) cryoablation. Overall survival (OS),
recurrence-free survival (RFS), and disease-free survival (DFS)
rates were estimated using Kaplan and Meier product-limit estimator.

Results: One hundred and ten TA for 109 lesions in 109
patients (66 male and 43 females, average age 68 years) were
included in this study. There were 80 patients in group (A)
and 29 patients in group (B). There was no statistically sig-
nificant difference in the clinical characteristics (demographics,
clinical presentation, renal tumors size, tumor histology and
grade), complication rate, and local recurrence at the ablation
site or development of metastasis from RCC. Sixty-three
(58%) patients had another primary cancer; 46 and 17 patients
in groups A and B respectively (p = 0.917). The Median OS
was 8.39 years. The OS for whole patient population was
68%, 59% and 38% at 5, 8 and 10 years. The metastasis free
survival (MFS) and cancer specific survival (CSS) are 100%.
There was no statistically significant difference in 5- and 8-
overall survival (p = 0.831), recurrence free survival (p =
0.448) and disease-free survival (p = 0.906) between both
groups.

Conclusions: Radiofrequency ablation and cryoablation are
equally safe and effective methods for treating small renal tumors.
Long-term follow-up data reveals thermal ablation in properly
selected T1a RCC patients provide a favorable long-term oncologic
outcome.

3:27 PM Abstract No. 243

Microwave ablation vs cryoablation in the
treatment of T1a renal cell carcinoma: a single-
center comparison of safety and outcomes
J. Titano1, B. Hong1, D. Biederman1, L. Liu1,
M. Ranade2, V. Bishay3, R. Patel4, E. Kim4,
F. Nowakowski4, R. Loockstein5, A. Fischman1; 1Icahn
School of Medicine at Mount Sinai, New York, NY;
2Mount Sinai Hospital, New York, NY; 3Icahn School of
Medicine at Mount Sinai Hospital, New York, NY;
4Mount Sinai Medical Center, New York, NY

Purpose: To compare the safety and efficacy of percutaneous
ablation of T1a renal cell carcinoma (RCC) performed utilizing
microwave ablation (MWA) and cryoablation (CRYO).

Materials: Retrospective analysis spanning 9/2006 to 9/2014 was
performed to identify RCC patients treated with MWA or CRYO.
37 patients with RCC underwent 40 percutaneous ablation pro-
du relations during the study period. 22 CRYO procedures (mean tu-
mor diameter: 2.6 ± 0.9 cm, mean RENAL score: 7.3 [range 4-10],
mean PRAC score: 8.3 [range 4-11.5]) were performed for 20
patients (age: 69.9 ± 8.1 years, male sex: 65%). 18 MWA pro-
dcedures (mean tumor diameter: 2.4 ± 0.8 cm, mean RENAL score:
7.2 [range 4-10], mean PRAC score: 7.7 [range 4-11.5]) were
performed for 18 patients (age: 66.8 ± 12.8 years, male sex:
61.1%). Outcomes variables included technical success, pre- and
posttreatment lab values, complications, imaging response, and
overall survival.

Results: Technical success was achieved in all cases. There
was no significant difference in baseline renal function be-
tween MWA (BUN: 19.6 ± 7.2 mg/dl, creatinine: 1.4 ± 0.8
mg/dl) and CRYO (BUN: 24.6 ± 16.0 mg/dl, creatinine: 1.2 ±
0.5 mg/dl) groups (p = 0.238 and p = 0.465 respectively) or
significant change in either BUN post-ablation for MWA and
CRYO (p = 0.852 and p = 0.805 respectively) or creatinine
(p = 0.355 and p = 0.599 respectively). There were 7 com-
lications (MWA:5, CRYO:2) including 6 perinephric
hematomas and an episode of urinary retention, 2 being major (SIR C) complications, without significant difference in the complication incidence between the 2 groups (p = 0.259). At median follow-up time of 3.2 years, 7 instances of disease progression (Cryo:5, MWA: 2) occurred at an average of 14.7 months post-ablation with no difference in disease progression between modalities (p = 0.205). Overall cohort survival was 5.1 (95% CI: 4.3–6.0) years with no significant difference between treatment groups (p = 0.486).

Conclusions: There is no difference in technical success, renal function change, complication incidence, imaging outcomes, or overall survival in RCC patients treated with either microwave ablation or cryoablation. Overall survival in the present cohort was 5.1 (95% CI: 4.3–6.0) years.

3:36 PM Abstract No. 244
Long-term (3-year) outcomes of microwave ablation of T1a small renal masses using a gas-cooled probe

L. Liu1, M. Hsu2, R. Patel3, E. Kim3, F. Nowakowski3, R. Lookstein2, M. Ranade2, V. Bishay4, A. Fischman5; 1Rush University Medical Center, Chicago, IL; 2Mount Sinai Hospital, New York, NY; 3Mount Sinai Medical Center, New York, NY; 4Icahn School of Medicine at Mount Sinai Hospital, New York, NY; 5Icahn School of Medicine at Mount Sinai, New York, NY

Purpose: To assess long-term safety and efficacy of percutaneous microwave ablation (MWA) using a gas-cooled probe to treat T1a small renal masses (SRM).

Materials: From 12/2011 to 7/2014, 15 T1a SRMs in 14 patients (9 men, 5 women; mean age 64) underwent MWA treatment with gas-cooled probe (Neuwave Medical, Madison, WI) with MRI or CT imaging follow-up for at least 3 years (mean 3.9 years; range 3.0-5.6). Lesion size, mRENAL, and Percutaneous Renal Ablation Complexity (P-RAC) scores (Mansilla 2017) were calculated for each SRM. Medical records were reviewed for biopsy results, procedural details, and outcomes. Long-term progression (LTP) was defined in years from dates of ablation to documented recurrence. Mean maximum SRM diameter, mRENAL, and P-RAC were compared between lesions of different outcomes using unpaired t tests.

Results: Biopsy found: clear cell (n = 5), papillary (n = 4), and unspecified (n = 6). Fuhrman scores were available for 7 SRMs with a mean of 2.4 (SD 0.58). No correlation was found between biopsy results and LTP or hydrodissection use. Mean SRM diameter was 2.3 cm (SD 0.9 cm), mean mRENAL was 7.2 (SD 1.7), and mean P-RAC was 7.4 (SD 2.2). LTP occurred in 3 patients with 4 SRMs (21%) at 1.3, 1.3, and 1.5 years. 2 were retreated with MWA with no recurrence (mean post-retreatment follow-up 2.7 years). Mean SRM diameters for patients with LTP and without were 1.9 cm and 2.4 cm respectively (p = 0.39). The difference in mean mRENAL and P-RAC scores were 9.0 vs 6.5 (p = 0.0095) and 7.3 vs 7.4 (p = 0.94) for patients with LTP and without respectively. 4 SRMs required hydrodissection during ablation. Mean size did not differ between lesions with hydrodissection and without (2.3 cm, 2.2 cm; p = 0.86). Mean mRENAL and P-RAC scores for lesions with and without hydrodissection were 7.3 vs 7.4 (p = 0.93) and 9.1 vs 6.7 (p = 0.058). Progression-free survival, cancer-specific survival, and overall survival were 79%, 100%, and 100% respectively. There were no major or minor adverse events.

Conclusions: Three-year imaging follow-up of T1a SRMs found MWA to be durable and safe. LTP was associated with higher mRENAL scores than progression-free patients. SRM size or P-RAC score alone was not predictive of either LTP or hydrodissection use.

3:45 PM Abstract No. 245
Renal ablation using a 915-MHz synchronous wave microwave ablation system: safety and short-term follow-up

R. Hardman1, D. Besachio1, R. O’Hara2, K. Marashi1; 1University of Utah, Salt Lake City, UT; 2University of Utah/Huntsman Cancer Center, Salt Lake City, UT

Purpose: To evaluate the safety and outcomes using a 915-MHz synchronous wave microwave ablation system in renal ablation of T1A and T1B tumors.

Materials: The study was IRB approved and HIPAA compliant. Renal ablation cases were retrospectively reviewed from July 2013 to August 2017. Microwave ablation cases were evaluated by imaging and chart review. Patient demographics, imaging follow-up, and complications were reviewed. Microwave ablation was performed using a 915-MHz ablation system. Number of probes, wattage, and ablation time were determined by the interventional radiologist. If diagnosis was unknown, biopsy was performed at the time of the ablation.

Results: 88 ablations were performed at a single institution with 58 patients undergoing microwave ablation. Follow up was at least 3 months with average follow-up of 9 months ± 7.8 months. Average lesion size was 2.3 ± 0.95 × 2.0 ± 0.77 × 2.3 ± 0.97 cm. The average probes placed was 1.93 ± 0.62 with average ablation energy of 1137 ± 493. Biopsy showed 30 renal cell carcinomas, 6 oncocytomas, 5 angiomylipomas, 13 non-diagnostic biopsies, and 4 other pathologies. Two patients had residual tumor noted on follow-up CT, both with T1B tumors, which were subsequently completely treated with follow-up ablation. There were one minor and two major complications following ablation: one pneumothorax from probe placement not requiring chest tube, one renal bleed requiring transfusion, and one acute kidney injury which improved with conservative management.
Conclusions: Ablation has been reported using 2450-MHz system in the kidney. This series represents one of the larger short-term follow-up studies for 915 MHz. 915-MHz ablation is safe and effective for renal ablation with low complication rates.

3:54 PM Abstract No. 246

Intraprocedural renal hilar nerve block during percutaneous renal tumor ablation: a postoperative opioid-sparing pain management technique

D. Besachio1, R. O’Hara2, B. Hamilton1, R. Hardman1; 1University of Utah, Salt Lake City, UT; 2University of Utah/Huntsman Cancer Center, Salt Lake City, UT

Purpose: To determine if the addition of a renal hilar nerve block during percutaneous renal ablation decreases post-procedural pain.

Materials: Subject population consists of 67 patients who underwent 87 ablations from July 2013 – July 2017. 34 patients in the study population received a renal hilar block during the ablation procedure and 33 received no hilar block. Eight patients in the renal hilar block group and 12 in the non-hilar block group had previously been diagnosed with chronic pain and/or clinical depression. Renal hilar block was performed under CT guidance during renal mass ablation utilizing a 21-gauge, 15-20 cm needle directed to the renal hilum at the peripheral aspect of the renal artery. A combination of 10 mL of 2% lidocaine and 10 mL of 0.5% bupivacaine was administered for the hilar block. Postprocedural narcotic utilization was recorded in the patient’s electronic medical record and converted to morphine equivalent doses (MEQ) using the Centers for Disease Control and Prevention prescribing guidelines. Descriptive statistics and a two-tailed, unpaired Mann-Whitney t-test was performed to analyze these data and compare the median values of MEQs utilized in the hilar versus non-hilar block groups.

Results: Patients without hilar block required nearly twice the amount of narcotic pain medication (30 versus 15.6 MEQ, P = 0.0085), there is a trend toward significance. Evaluation of our sub-population of patients with depression and/or chronic pain (DCP) demonstrated a significant difference between MEQs administered between hilar block and non-hilar block groups (p = 0.0015). There was no significant difference between the MEQ dose utilized by patients with DCP and patients without these diagnoses within the hilar block group (15 versus 15.6 MEQs).

Conclusions: There is decreased utilization of narcotic pain medication following percutaneous renal tumor ablation when intraprocedural renal hilar nerve block is performed. Given that renal hilar block can be performed simultaneously with percutaneous ablation under CT guidance, consideration should be given to performance of this simple procedure as part of an overall strategy to potentially mitigate postoperative pain.

4:03 PM Abstract No. 247

Surveillance, Epidemiology, and End Results (SEER) survival study of stage T1a renal cell carcinoma treated with ablation vs. partial nephrectomy: a propensity-matched analysis

M. Zhou1, A. Mills2, C. Noda3, R. Ramaswamy4, O. Akinwande6; 1Washington University School of Medicine, St. Louis, MO; 2Mallinckrodt Institute of Radiology/Washington University, St. Louis, MO; 3Washington University School of Medicine, St. Louis, MO; 4Mallinckrodt Institute of Radiology, St. Louis, MO; 6Washington University School of Medicine in St. Louis, St. Louis, MO

Purpose: To analyze survival in stage T1a renal cell carcinoma (RCC) treated with ablation compared to partial nephrectomy, using the Surveillance, Epidemiology, and End Results (SEER) database.

Materials: Using the SEER database, we identified cases of diagnosed RCC who underwent partial nephrectomy or ablation between 2004 and 2013. Patients were included if they had a mass <4 cm and had partial or subtotal nephrectomy. We excluded patients with tumor extension outside the kidney or any nodal or distant metastases. Descriptive statistics were performed with Chi-squared and Wilcoxon sum rank tests for categorical and continuous variables respectively. Kaplan-Meier (KM) statistic and cox proportional hazards regression (CR) were performed. Propensity score matching (matched by age, sex, race, grade, tumor size, and tumor extension) was used to reduce treatment-selection bias and match pairs of subjects with similar background variables. KM and CR analyses were repeated after propensity matching.

Results: A total of 4592 patients were included (809 receiving ablation and 3783 receiving partial nephrectomy). Patients who underwent ablation were more likely to be older, with larger tumors, and lower tumor grade. Before propensity matching, there was significantly better overall survival (OS) and cancer-specific survival (CSS) in the partial nephrectomy group (93.6% 5-year survival) compared to the ablation group (81.9% 5-year survival) with p<0.0001. Propensity matching generated 1222 matched pairs with similar background characteristics in all background variables. Again, there was better OS in the partial nephrectomy group (91.0% vs 86.3% 5-survival, p = 0.0457), but the curves are not as divergent as in the pooled cohort. However, there is no significant difference in CSS between the treatment groups (p = 0.4023) in the propensity matched cohort.

Conclusions: In this propensity-matched population study of stage T1a RCC, partial nephrectomy offers slightly better OS but similar CSS compared with ablation.
Percutaneous thermal ablation of endophytic renal cell carcinoma: evaluation of safety and oncologic outcomes

S. Alshehri1, A. Alhazzani2, D. Wiseman3, D. Cool1, A. Mujoomdar2; 1University of Western Ontario, London, ON; 2King Saud Medical City, Riyadh, SA; 3London Health Sciences Centre, London, ON

Purpose: To evaluate the safety and efficacy of percutaneous thermal ablation in patients with endophytic renal cell carcinoma (RCC).

Materials: A retrospective single-center review of RCC ablations performed from November 2011-May 2016 was undertaken. Images were evaluated to determine the location of the RCC. Masses that extend into the sinus fat or had less than 50% of the tumor outside the renal cortex was defined as an endophytic. Patients with exophytic RCC were excluded. Patient demographics, tumor imaging characteristics (RENAL nephrometry score), kidney function, clinical and imaging outcomes and complications were assessed. Complete ablations were compared to incomplete primary responses with a t test.

Results: A total of 39 ablation procedures were performed in 32 patients (17 men and 15 women; median age 66.5 ± 11.5 years) treated with RFA (21), MWA (2) or cryoablation (16). Mean tumor diameter was 2.9 ± 1.0 cm (1.2 – 5.6). Complete response (absent enhancement of treated tumor on contrast-enhanced CT or MRI) was seen in 25 patients (78%). Residual tumor was seen in 7 patients (22%) who returned for a second ablation, 6 of which had successful treatment and one patient required a nephrectomy. There was a trend toward increased RENAL nephrometry scores in the patients with viable residual tumor (7.9 ± 1.2, range 6.0-9.0) as compared to those with complete tumor coagulation (6.6 ± 2.1, range 5.0-9.0) though statistical significance was not reached (p = 0.16). Median follow-up was 27 ± 15.1 months (range, 7-62). The progression-free survival rate was 96% (31 of 32). A major complication (SIR classification system) occurred in one patient (3%); a chronic urine leak requiring long-term nephrostomy tube drainage. No major bleeding, infection, or other complications were recorded.

Conclusions: Percutaneous thermal ablation of endophytic RCC provides a safe and effective treatment with an acceptable risk and durable outcomes at approximately two years follow-up. RENAL nephrometry score may help to predict tumors at risk of incomplete ablation.

Safety and efficacy of percutaneous irreversible electroporation in treating endophytic renal masses: a single-center experience

M. Doshi1, S. McLafferty2, P. Mohan3, A. Moscowitz4, A. Echemique5, R. Lencioni1, G. Narayanan6; 1University of Miami, Miami, FL; 2University of Miami/Jackson Health System, Miami, FL; 3University of Miami Miller School of Medicine, Miami, FL; 4N/A, Coral Gables, FL; 5University of Miami, Coral Gables, FL; 6University of Miami- Miller School of Medicine, Miramar, FL

Purpose: Percutaneous irreversible electroporation (IRE) has the ability to treat renal masses while sparing nearby collecting system and vasculature. This makes IRE a viable treatment option for endophytic and hilar tumors not amenable to conventional ablation techniques. The purpose of this study is to evaluate safety and efficacy of IRE in endophytic renal masses.

Materials: Retrospective review between April 2011 and Sep 2017 yielded 10 patients (2 female, 8 male) aged 45-85 years (mean, 65.3 y), who underwent CT-guided IRE for 11 renal masses. Seven lesions were stage T1a, 2 were T1b, and 1 was a recurrence in the nephrectomy bed with mean tumor size of 3.1 cm (range, 2-4.5 cm). The mean RENAL Nephrometry Score was 7.5 (Range, 4-10). Eight out of 11 tumors were predominantly endophytic, 3 of which had hilar extension. One tumor was in a transplant kidney and 2 were in a solitary kidney. On histopathology, 7 were clear cell carcinomas, 2 were oncocytic neoplasms, 1 was papillary cell carcinoma, and 1 biopsy was nondiagnostic. Technical success (TS) and recurrence were determined by enhancement characteristics on follow-up imaging (CT or MRI). Complications were assessed as per SIR Classification System for Complications by Outcome. Pre- and postprocedure creatinine (Cr) and GFR were analyzed using a paired samples t-test to evaluate for a significant difference (p < 0.05).

Results: Technical success was achieved in 7/9 tumors. Two patients were excluded from evaluation for TS and recurrence as initial follow-up imaging had yet to be performed. The mean follow-up interval was 13.3 months (range, 1-56 months). Disease recurrence was observed in 0/7 at 1 month and 1/4 patients at 6 months post IRE; 3 patients were lost to follow-up. There were no major complications; 1 post procedure pneumothorax was noted which was a Class A complication. There was no significant statistical difference in pre- and postprocedure Cr (p = 0.923) and GFR (p = 0.978).

Conclusions: Percutaneous IRE appears to be a safe, effective and nephron-sparing treatment option for endophytic renal masses in close proximity to blood vessels and renal collecting system where conventional ablative techniques may not be feasible.
Outpatient percutaneous CT-guided radiofrequency ablation of osteoid osteoma: factors associated with clinical success
M. Rochon1, J. Kachura2; 1University Health Network and Mount Sinai Hospital, Toronto, Canada, Toronto, ON; 2Toronto General Hospital, Toronto, ON

Purpose: To evaluate the technical and clinical success of outpatient percutaneous CT-guided radiofrequency ablation of osteoid osteoma, and identify any associated factors for clinical success.

Materials: Single-institution retrospective review from September 2004 to September 2017 of 181 outpatient percutaneous CT-guided radiofrequency ablations performed on 172 patients (133M/39F) with diagnostic imaging and clinical symptoms consistent with osteoid osteoma. Mean patient age was 26 years ±10.1 (range, 12-62). 148 patients had lower extremity appendicular skeleton lesions, 20 had upper extremity lesions, and 4 had axial skeleton lesions. Clinical and imaging follow-up was available in 99 patients, with a mean follow-up time of 4.8 months (range, 1-65 months). Both temperature and impedance-based devices were used by 4 interventional radiologists.

Results: Technical success was 99% (180/181 possible ablations) with a failure occurring from a broken drill bit within prominent hyperostosis. Clinical success, defined as resolution of pain postprocedure, was achieved in 86 patients (86/99 patients = 87%), whereas 13 did not have complete resolution of pain. Eight of the 13 patients without initial clinical success underwent a second ablation, with 2 having clinical success, 1 not, and 5 lost to follow-up. Those patients having a second ablation had a mean nidus size of 10.6 mm, which trended towards being larger than the overall mean nidus size of 6.9 mm (p-value 0.054). There were 19 intraarticular lesions (with a 92% success rate) and 153 extraarticular lesions (with an 86% success rate). There was no significant difference between the success rates of intra vs. extraarticular nidus location, nidus size, patient gender, or temperature vs. impedance based devices. There were 6 complications (3 skin burns, 1 infection, 2 nerve/tendon injuries), for a complication rate of 3.3% per procedure (3/181).

Conclusions: Outpatient percutaneous CT-guided radiofrequency ablation of osteoid osteoma is safe and effective, with no significant differences in clinical success based on nidus location or size, patient gender, or type of device used.
concordance with clinical/imaging diagnosis. Details of the procedure, such as imaging modality used, technical success, procedure time, radiation exposure, and complications of each procedure were analyzed.

Results: All patients presented with classical symptoms with an average age of 12.1, and 82% were male. The average duration of pain was 11 months and 91% reported regular NSAID use prior to cryoablation. The average nidus size was 9.7 mm. A 100% technical success rate was achieved with 60% of patients having a concordant biopsy. There was a significant reduction in numeric pain scales from an average of 7 out of 10 before to an average of 0 after the procedure (p = 0.003). A total of 3 self-limiting complications were reported after the procedure: one patient reported skin blistering and two presented with temporary nerve injury. There was no significant difference in procedure time, radiation exposure, and technical success between the two types of CT scanners used (p > 0.05).

Conclusions: Adequate symptom relief can be achieved with percutaneous cryoablation, which is an effective alternative to other percutaneous techniques or surgical resection in the treatment of osteoid osteoma.

3:27 PM Abstract No. 253

Palliative radiofrequency ablation of spinal metastases: safety, technical success, and short-term efficacy

J. Sandhu1, V. Madhusoodanan2, A. Amin3, I. Kably4;
1University of Miami Miller school of medicine, Miami, FL; 2N/A, Miami, FL; 3University of Miami Miller School of Medicine, Miami, FL; 4University of Miami, Miami, FL

Purpose: External beam radiation therapy is the standard approach for treatment of spinal metastases, but radiofrequency ablation (RFA) and kyphoplasty are efficacious. The aim of this study is to assess the safety, technical success and short-term efficacy of RFA and kyphoplasty of spinal metastases.

Materials: An IRB approved retrospective study of 48 patients (24F, 24M; mean age 60.2) who underwent a total of 111 RFAs. The data was collected from electronic medical records. Laser guidance software was used to access spinal metastases and active cooling was used to minimize injury to neural and adjacent tissue. Balloon kyphoplasty was performed, minimizing cement extravasation. Measured in this study: patient demographics, pain, type of lesion, ablation time and approach, and number of ablations. Safety was assessed by performing a full neurologic exam before and after the procedure. Technical success was measured by the ability to access and ablate the metastases. Clinical efficacy was measured by monitoring pain reduction, using the Visual Acuity Score (VAS).

Results: The most common types of cancer were breast (n = 12) and prostate (n = 9). 40 patients (83%) had multiple lesions at presentation vs. 8 (17%) with a single metastatic lesion. The most common lesions were lytic (66.7%), blastic (20.8%) and mixed (12.5%). 45.8% of patients had prior radiation treatment. Most common lesions were lytic (66.7%), blastic (20.8%) and mixed (12.5%). 45.8% of patients had prior radiation treatment.

Results: Adequate symptom relief can be achieved with percutaneous cryoablation, which is an effective alternative to other percutaneous techniques or surgical resection in the treatment of osteoid osteoma. Following ablation, patients were not treated with any further therapy, but were followed by surveillance imaging to determine the progression-free rate.

Materials: Patients had histologically/cytologically confirmed high-grade metastatic sarcoma stable on 6-12 cycles of one chemotherapeutic regimen with lesions that could be accurately measured in at least one dimension as >10 mm on cross sectional imaging, and could have no more than 10 treatable lesions. Eligible patients had their lesions ablated using the preferred ablation modality of the operator (cryoablation and radiofrequency ablation) based on lesion location/characteristics. Chemotherapy was stopped at initiation of ablation therapy and patients were followed with CT scans every 9 weeks for the first year, every 12 weeks for the second year, and then every 6 months until a new biopsy-proven lesion or a previously ablated lesion grew by 20% in size. The primary outcome was to determine the progression-free rate at 3 months.

Results: Over three years, eight patients enrolled who were eligible for this study. Histologies included leiomyosarcoma, malignant peripheral nerve sheath tumor, myxoid liposarcomas, and pleomorphic rhabdomyosarcoma. The patients had between 1-8 lesions on CT at the start of chemotherapy. Following chemotherapy, patients had 1-4 sites of residual disease requiring ablation. The lesions ablated included pulmonary nodules and retroperitoneal and peritoneal lesions. Despite the fact that the trial was stopped early due to low enrollment, there was a 3-month progression-free rate (PFR) of 75% and median progression-free survival (PFS) was 19.74 months. There were two major complications of pneumothoraces following lung cryoablation requiring chest tubes.

Conclusions: This is the first prospective study of ablation therapy following stability on chemotherapy in patients with metastatic sarcoma and strongly supports ablation for local tumor progression.
control and maintenance therapy with significant PFS along with a chemotherapy-free holiday.

3:45 PM  Abstract No. 257

Role of radiofrequency ablation as a salvage treatment for recurrent fibromatosis: retrospective analysis
P. Patil1, S. Kulkarni2, N. Shetty2, A. Polnaya2, K. Gala1, R. Chivate1, 1Tata Memorial Centre, Surat, Gujarat; 2Tata Memorial Hospital, Mumbai, Maharashtra; 3Tata Memorial Hospital, Mumbai, Parel

Purpose: To evaluate the safety and efficacy of RFA in managing recurrent fibromatosis.

Materials: A retrospective analysis of 40 fibromatosis patients treated with 109 sessions of RFA from January 2008 to March 2015 was done. Inclusion criteria were recurrent fibromatosis refractory to primary treatment, i.e., surgery, CT or immunotherapy. RFA was done under CT guidance. Patients were followed up after 1 month of session and then 6, 12 and 24 months to assess clinical benefits and radiological response. Response evaluation was done clinically by improvement in the restriction of movements (ROM) by Musculoskeletal tumor society scoring system (MSTS) and pain by Visual analogue scale (VAS) and radiologically by calculating change in volume of the lesion and percentage of necrosis at follow-up.

Results: A total of 109 sessions of RFA was done in 40 patients with fibromatosis (mean number of sessions, 2.5). Mean follow-up was 38 months (range, 1-96 months). 13 patients had involvement of upper limb, 11 lower limb, 5 chest wall and 11 Abdomen and pelvis. Restriction of movements For Upper limb: Preprocedure mean MSTS score: 18.60 Post procedure mean MSTS score: 23.46 Restriction of movements For Lower limb: Preprocedure mean MSTS score: 20.30 Post procedure mean MSTS score: 25.00 Pain score (visual analogue score) reduced in patients having pain from 6.56 to 2.0. Quantification of reduction of size was 0-25% in 20 patients, 26-50% in 9 patients, 51-75% in 8 patients and 76-99% in 4 patients. Complications: Postprocedure pain was the chief complaint, which subsided with analgesics. Two patients had neurological deficit (foot drop) and one patient had ground pad burns which managed conservatively. Extensive necrosis in one case needed aspiration for symptom relief.

Conclusions: Radiofrequency ablation of recurrent fibromatosis is a safe and effective treatment option. Procedure is well tolerated, with significant improvement in quality of life and good long-term locoregional disease and symptom control.

4:03 PM  Abstract No. 259

Utility of metal artifact reduction to improve visualization of therapeutic ice ball in CT-guided cryoablation of musculoskeletal metastases
A. Nagaraj1, E. Lin2, G. Chintalapani3, J. Ramirez Giraldo4, R. Sheth2, A. Tam2, S. Yevich2; 1Baylor College of Medicine, Houston, TX; 2The University of Texas MD Anderson Cancer Center, Houston, TX; 3Siemens Medical Solutions USA, Inc., Hoffman Estates, IL; 4Siemens Medical Solutions USA, Inc., Malvern, PA

Purpose: To compare outcomes between patients who underwent percutaneous cryoablation of extra-abdominal desmoid tumors as first-line versus salvage therapy.

Materials: We performed a retrospective analysis of 22 patients who underwent percutaneous cryoablation of extra-abdominal desmoid tumors between December 2008 and March 2017. Patients were treated with first-line cryoablation (treatment-naive; n = 11) or salvage cryoablation (disease progression after surgical resection, radiation therapy, and/or systemic therapy; n = 11). Primary endpoints were progression-free survival (PFS) after the first cryoablation and PFS after one or more sessions of cryoablation. PFS was calculated using the Kaplan-Meier method. Predictors of disease progression after the first cryoablation were determined using the log rank test and the Cox proportional hazards model.

Results: Tumors sites included abdominal wall (n = 10), back (n = 4), chest wall (n = 6), and upper extremity (n = 2). Disease control was obtained in 15 of 22 patients (68%) after the first cryoablation. Univariate analysis identified age younger than 25 years old (HR: 5.74, P = 0.010), salvage therapy (HR: 8.64, P = 0.017), transaxial diameter >5 cm (HR: 11.37, P = 0.006), and hydrodissection (HR: 0.11, P = 0.041) as predictors of disease progression after the first cryoablation. Univariate analysis found no significant difference in PFS after the first cryoablation based on gender, prior pregnancy, gravidity, or tumor site. Multivariate analysis identified salvage therapy as the only independent predictor of disease progression after the first cryoablation (HR: 13.85, P = 0.05). Five-year PFS rate for all patients after one or more sessions of cryoablation was 88.9% (95% CI 71-100). Disease was ultimately controlled in 21 of 22 patients after one or more sessions of cryoablation (95.5%).

Conclusions: A single session of cryoablation appears to provide better control of extra-abdominal desmoid tumors when used as first-line therapy compared to salvage therapy. Given that long-term disease control can be achieved with first-line cryoablation, cryoablation is an appropriate treatment consideration for select treatment-naive patients with extra-abdominal desmoid tumors.

3:54 PM  Abstract No. 258

Percutaneous cryoablation of extra-abdominal desmoid tumors as first-line and salvage therapy
J. Mandel1, E. Ziv1, H. Yarmohammadi1, F. Boas1, M. Keohan1, S. D’Angelo1, M. Gounder1, S. Singer1, A. Crago1, J. Erinjeri1; 1Memorial Sloan-Kettering Cancer Center, New York, NY

Purpose: To evaluate the effects of metal artifact reduction (MAR) on cryoprobe-induced artifact for improvement of therapeutic ice ball visualization in CT-guided cryoablation of musculoskeletal (MSK) metastases.
Materials: An iterative MAR algorithm (Siemens, Germany) was retrospectively applied to 12 cases of CT-guided MSK cryoablation in 11 patients from November 2016 to August 2017. The final cryoablation CT image with greatest metal artifact caused by the cryoprobe was compared before and after application of MAR. Three experienced interventional radiologists performed a blinded, qualitative evaluation of side-by-side images with and without MAR using a modified 4-point scale (0-3; 0 denotes no artifact, 3 severe artifact). The metal artifact beyond and adjacent to the probe, metallic artifact compromising the ice ball margins, and visualization of critical structures within 1 cm of the margins was scored. Quantitative measurements of CT attenuation (Hounsfield Unit) and standard deviation (noise) were made in four locations: beyond the probe, directly overlaying the probe tip, and within and outside of the ice ball margins. Wilcoxon signed-ranks test was used to compare variables.

Results: Qualitative analysis showed image quality improvement in MAR images beyond the probe tip (mean score 1.6/0.9, without MAR vs with MAR, p = 0.002), adjacent to the probe (0.8/0.4, p = 0.011), and ice ball conspicuity (1.1/0.5, p = 0.007). There was a trend towards improved visualization of critical structures within 1 cm of ice ball margins (0.8/0.4, p = 0.07). Quantitative analysis confirmed a noise decrease for MAR images beyond the probe (HU 90.5 ± 57.6, 64.8 ± 48.5, without MAR vs with MAR; p = 0.002) and within the ice ball (25.1 ± 8.7, 20.6 ± 7.0; p = 0.008). Noise overlying the probe tip and at critical structures was not significantly improved.

Conclusions: MAR provides both qualitative and quantitative improvements for the visualization of the therapeutic ice ball during CT-guided cryoablation of musculoskeletal metastases.

4:12 PM Abstract No. 260

Recalcitrant desmoid tumors: does cryoablation help?
R. Shaikh1; 1Boston Childrens Hospital, Boston, MA

Purpose: Desmoid tumors are highly aggressive rare musculoskeletal tumors which often recur after treatment. Conventional treatments include surgical resection, radiation, systemic therapy, and neoadjuvant radiation with or without chemotherapy. Reported mean local failure rates of 22%, 35%, and 28% for radiation alone, surgery alone, and radiation plus surgery, respectively. Reported mean stable disease rates of 91% and 52% for cytotoxic and noncytotoxic chemotherapy, respectively. Cryoablation can be used in isolation or as adjuvant to chemotherapy/radiotherapy in large, recalcitrant desmoids to promote faster tumor necrosis and shrinkage from critical structures. It also helps in long-term control of tumor progression. We present our experience with percutaneous cryoablation of desmoid tumors with the objective of showing the safety and efficacy of this treatment.

Materials: Seven patients with symptomatic and recurrent progressive desmoid tumors in post resection and chemotherapy who underwent percutaneous cryoablation, from September 2012 to September 2017. The desmoids were in anatomically challenging locations. Patients were evaluated in an interdisciplinary tumor conference before being referred for cryoablation. Percutaneous image-guided cryoablation was performed using Argon and Helium gases in a single or staged sessions. Pre-procedure and follow-up clinical and imaging evaluation was done to assess outcome.

Results: Following cryoablation, there was significant improvement in symptoms and tumor size regression followed over 1 to 3 years. There were no major complications.

Conclusions: Percutaneous image-guided cryoablation is safe and effective and should be considered early in the treatment of recalcitrant desmoid tumors.

4:21 PM Abstract No. 254

Percutaneous cryoablation for palliation of pain from breast cancer bone metastasis
A. Deipoly1, S. Solomon2, C. Sofocleous2, Y. Bryce1, M. Maybody1; 1Memorial Sloan Kettering Cancer Center, New York, NY; 2Memorial Sloan Kettering, New York, NY; 3Memorial Sloan-Kettering Cancer Center, New York, NY

Purpose: Percutaneous cryoablation may be offered for palliation of painful sites of disease. We describe our experience treating patients with painful bone metastases.

Materials: Six female patients with metastatic breast cancer, with a mean age of 52 (range, 40-68) years, underwent palliative cryoablation of single painful lytic bone lesions, from July 2012 to September 2016. Retrospective chart review was conducted to characterize technical features of the procedures and outcomes. Numeric pain score (NPS) was used to assess treatment response.

Results: Sites included the sternum (1), glenoid (1), pubic bone (1), iliac bone (1), and rib (2), with a mean lesion volume of 5.1 (range, 2.5-8.6) cc. Biopsy was performed in 3 cases at the time of ablation. Five procedures were CT-guided, and 1 procedure PET/CT-guided. Five procedures were performed with the Endocare system, and 1 with Galil probes, with 2-5 probes used in each case. Procedures were performed with a freeze-thaw-freeze-thaw protocol of 10-12, 4-8, 6-12 and 2-8 minutes respectively. Prevention of non-target ablation was performed in all cases, involving warm compresses in 2 cases and pneumo- or hydrodissection in 4 cases for skin protection; an artificial pneumothorax was created for lung protection in 1 case; pneumodissection and intraoperative nerve monitoring were used in 1 case for nerve protection.

There were 4 responders (67%), 2 who had complete resolution of pain (33%) and 2 with partial response (33%) with 2-6 NPS improvement. Two failures (33%) were both due to collapse of periarticular targets, with worsening of preexisting associated pathological fractures. Two adverse events were noted; 1 patient had a postprocedure cellulitis requiring antibiotics and 1 had track seeding that was incidentally noted and did not change management.

Conclusions: Cryoablation of painful bone metastases due to breast cancer may be offered as a safe palliative treatment. Most patients will experience improvement or resolution of pain. Bone ablation alone may not be sufficient to palliate pain when a pathological fracture is present.
Radioembolization: Applications

Tuesday, March 20, 2018
3:00 PM–4:30 PM
Room: 406B

3:00 PM Abstract No. 261

Radioembolization is cost effective in intrahepatic cholangiocarcinoma: a SEER-Medicare population study
A. Ghodadra1, J. Raja2, S. Stein1, J. Lacy1, H. Kim1;1Yale School of Medicine, New Haven, CT; 2Yale New Haven Hospital, New Haven, CT

Purpose: To analyze cost effectiveness of radioembolization in the treatment of intrahepatic cholangiocarcinoma (ICC) using the Surveillance, Epidemiology, and End Results (SEER) Medicare cancer database.

Materials: Cost as measured by total treatment related reimbursement in patients diagnosed with intrahepatic cholangiocarcinoma who received chemotherapy alone or chemotherapy and Y90 radioembolization was assessed in the SEER-Medicare cancer database (1999-2012). Survival analysis was performed and incremental cost effectiveness ratios were generated.

Results: The study included 585 patients. Average age at diagnosis was 71 years (SD: 9.9), with 52% male. Twelve percent of patients received chemotherapy with radioembolization (n = 72) and 88% of patients (n = 513) received only chemotherapy. Median survival was 1043 days (95% CI: 894-1244) for chemotherapy plus radioembolization and 811 days (95% CI: 705-925) for chemotherapy alone (p = 0.02). Patients receiving combination therapy were slightly younger (71 vs 69 years, p = 0.03). There was no difference in age at treatment, sex, race, or city size between treatment groups. Multivariable analysis showed a hazard ratio for progression for combination therapy versus chemotherapy alone of 0.76 (95% CI: 0.59 - 0.97, p = 0.029). Table 1 shows cost and cost effectiveness data. The incremental cost-effectiveness ratio (ICER), a measure of cost of each added year of life, was $50,058.65 per year (quartiles: $11,454.63, $52,763.28).

Conclusions: Combination therapy of ICC with chemotherapy and radioembolization can be a cost effective with a median cost of $50,058.65 per additional year of survival.

3:09 PM Abstract No. 262

Long-term toxicity after radioembolization with yttrium-90 for neuroendocrine tumor liver metastases
Y. Tomozawa1, Y. Jahangiri1, K. Farsad2, K. Kolbeck1, J. Kaufman1;1Dotter Interventional Institute, Portland, OR; 2Oregon Health and Science University, Portland, OR

Purpose: To evaluate long-term effects of yttrium-90 (Y-90) radioembolization (RE) for unresectable hepatic metastases of neuroendocrine tumors (NET).

Materials: 93 patients (47 females, 46 males; mean age 59) who underwent resin-based Y-90 RE were analyzed retrospectively. Variables associated with overall survival were analyzed using univariate and multivariate models. Changes in serologic values and imaging characteristics were assessed with long-term follow-up.

Results: 48 patients had unilobar RE and 45 had staged bilobar RE. Amongst 52 patients who had more than 1-year follow-up, significant increases in alkaline phosphatase, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were observed; however, only four patients experienced grade 3 serum toxicities. Liver injury and imaging signs of portal hypertension were observed more frequently in those treated with bilobar RE compared to unilobar RE. In multivariate analysis, ascites (P = 0.002) and extrapancreatic metastases (P = 0.038) at baseline were associated with poor survival. Median survival was 58.0 months in patients without extrapancreatic disease and 53.8 months in patients without baseline ascites, whereas median survival was significantly worse with extrapancreatic disease (21.1 months) and lowest with baseline ascites (7.3 months).

Conclusions: Bilobar radioembolization was a significant risk factor for long-term liver toxicity and portal hypertension. Significantly improved survival after radioembolization for NET liver metastases was observed in patients presenting with no extrapancreatic disease or baseline ascites.

3:18 PM Abstract No. 263

Multicenter evaluation of yttrium-90 selective internal radiation therapy for the treatment of metastatic pancreatic adenocarcinoma
A. Kim1, S. Frantz2, J. Brower2, N. Akhter2; 1Medstar Georgetown University Hospital, Washington, DC; 2Inland Imaging, Providence Sacred Heart Medical Center, Spokane, WA; 3University of Maryland Medical Center, Baltimore, MD

Purpose: To assess the efficacy and safety of selective internal radiation therapy (SIRT) with SIR-Spheres Y-90 resin microspheres in heavily pretreated patients with liver metastases from pancreatic adenocarcinoma.

Materials: From 2011 through 2017, 35 patients (27 men, 8 women; mean age 62.9 y) with metastatic pancreatic adenocarcinoma were treated with SIR-Spheres microspheres at 3 institutions and monitored with laboratory and imaging studies for 4-12 wk. Before SIRT, 34 patients had ≥1 chemotherapy lines, 11 had external beam radiation therapy, 12 had pancreatic surgery, 14 had pancreatic radiation, and 8 had other liver-directed therapies; 23 patients also had adjuvant chemotherapy. Tumor response was assessed with RECIST 1.1 and adverse events graded with CTCAE v4.0. Kaplan-Meier analyses were used to evaluate survival and combined with log-rank tests to identify predictors of survival.

Results: Imaging between 4 and 12 wk in 27 patients showed partial response in 8 (29.6%), stable disease in 10 (37.0%), and
progressive disease in 2 (7.4%) (7 not determined). Liver function tests showed a significant reduction of mean serum albumin after SIRT (from 3.7 ± 0.53 g/dL [baseline] to 3.3 ± 0.64 g/dL [week 4, P<.001] and 3.0 ± 0.70 g/dL [week 12, P<.001]), and a significant increase in mean ALP values (from 218.0 ± 174.47 IU/L [baseline] to 244.9 ± 132.49 IU/L [week 8, P = .008] and 313.9 ± 144.73 IU/L [week 12, P = .002]). Mean ALT, AST, and total bilirubin were mostly within normal range during the 12-week follow-up. Most frequent SIRT-related adverse events included fatigue (26 patients), abdominal pain (20), nausea (12), weight loss (11), and abdominal disturbances (9). Most complications were grade 1-2; only 3 patients had grade 3 (abdominal distension and ascites, and abdominal pain and fatigue) or grade 4 (AST and ALT elevation) toxicities. Median survival from diagnosis was 20.8 mo. Age, sex, extrahepatic disease, and ECOG performance status were not significant predictors of survival.

Conclusions: Y-90 SIRT meaningfully prolonged survival of heavily pretreated patients with liver metastases from pancreatic adenocarcinoma. Complications and liver toxicity remained acceptable and were rarely severe (grade ≥3).

3:27 PM Abstract No. 264

PI3K pathway mutations predict response on PET/CT after radioembolization as salvage therapy for heavily pretreated patients with breast cancer liver metastases

A. Deipolyi1, C. Riedl2, J. Bromberg2, C. Klebanoff2, F. Boas3, H. Yarmohammadi3, L. Brody3, C. Sofocleous3, Y. Bryce1, S. Chandralapaty2, E. Ziv1; 1Memorial Sloan Kettering Cancer Center, New York, NY; 2Memorial Sloan Kettering, New York, NY; 3Memorial Sloan-Kettering Cancer Center, New York, NY

Purpose: Transarterial radioembolization (RE) is an emerging treatment for patients with hepatic metastasis due to breast cancer. This single-center retrospective review was conducted to identify factors predicting favorable outcomes and survival after RE.

Materials: Thirty-one heavily pretreated female patients underwent RE between January 2011 and September 2017 (9 with glass and 22 with resin microspheres). Of these, 24 also underwent next-generation genetic sequencing with MSK-IMPACT or Sequenom, and 26 had PET/CTs available to document imaging response performed on average 38 ± 35 before and 80 ± 33 days after RE. Response was categorized as complete response when the SUVmax in the targeted liver segments decreased by >80%, partial response when SUVmax decreased by 30-80%, stable disease when a change in by normalized SUVmax between -30% and 30%, and progressive disease when normalized SUVmax increased by more than 30%.

Results: Kaplan-Meier survival analysis demonstrated a median survival after RE of 10.8 months. Complete or partial response was achieved in 18/26 (69%). PI3K pathway mutations were associated with imaging response (p = 0.006) but not survival (p = 0.58). Imaging response predicted longer survival (p = 0.005). Trends for lower bilirubin levels (p = 0.15), lower preprocedure neutrophil-lymphocyte ratio (p = 0.06), younger age (p = 0.15), and lower total bilirubin level (p = 0.06) to predict improved survival were not significant. Mutations in TP53, the MAPK-ERK pathway, hormonal status, and preradioembolization imaging variables (lung shunt fraction, arterial enhancement fraction, or tumor burden) did not correlate with imaging response (p > 0.05). Three (9.6%) patients had major adverse events after resin microsphere-radioembolization, including two with gastric ulcers managed conservatively and one with liver failure and death 26 days after the first lobar treatment.

Conclusions: These preliminary observations confirm the prognostic relevance of early interval follow-up imaging after RE to survival. Furthermore, these data suggest that genomic profiling may help predict which metastatic breast cancer patients could benefit most from RE.

3:36 PM Abstract No. 265

Safety and feasibility of integrating yttrium-90 radioembolization with capcitabine-temozolomide for grade 2 liver-dominant metastatic neuroendocrine tumors (CapTemY90): final report

M. Soulen1, U. Teitelbaum2, D. van Houten3, G. Deitrick4, N. Damjanov5, C. Gabrieli5, M. O’Hara5, K. Cengel6, J. Mondschein6, M. Dagli7, D. Metz8; 1University of Pennsylvania, Lafayette Hill, PA; 2University of Pennsylvania, Philadelphia, PA; 3University of Pennsylvania, Philadelphia, PA; 4UPHS, Wilmington, DE; 5Upenn, Philadelphia, PA; 6Hospital of the University of Pennsylvania, Moorestown, NJ; 7N/A, Philadelphia, PA; 8University of Pennsylvania, Department of Rad. Onc, United States

Purpose: Advanced NET tumor grade portends poorer disease control with both systemic and liver-directed therapies. An integrated treatment protocol combining capcitabine-temozolomide with yttrium-90 radioembolization (CapTemY90) for patients with liver-dominant grade 2 metastases was designed in the hopes of achieving synergistic improvement in liver disease control with no more than additive toxicities. This report describes the feasibility and safety of this integrated loco-systemic regimen.

Materials: The NET Tumor Board identified patients with unresectable Grade 2 neuroendocrine tumor liver-dominant metastases without contraindications to radioembolization or to CapTem. Initial therapy consisted of capcitabine 600 mg/m² twice daily for 14 days and temozolomide 150-200 mg/m² in two divided doses on Days 10-14, with 14 days between cycles. Once the patient had completed one cycle of CapTem with tolerable toxicity and undergone simulation angiography demonstrating eligibility for Y-90 radioembolization, the dominant lobe was radioembolized on Day 7 of the 2nd cycle of CapTem. For patients with bilobar disease, the other lobe was treated on Day 7 of the 3rd or 4th cycle. Clinical assessment was performed monthly and imaging every 3 months.

Results: 19/21 patients completed the prescribed therapy. Two did not have the planned second lobe radioembolization due to post-embolization toxicities. Adverse events were as expected for each therapy alone, including thrombocytopenia, fatigue, nausea, and post-embolization pain and hepatic dysfunction. ORR was 74% in the liver and 55% for extrahepatic tumor. Median PFS was not
reached at a mean follow-up of 27 months. PFS at three years was 67%, with 74% progression-free in the liver.

Conclusions: CapTemY90 is a feasible and safe integrated therapeutic regimen for intermediate-grade liver-dominant NETs. Toxicities were additive. Oncologic outcomes suggest synergy and provided the basis for design of a multicenter Phase 2 trial.

3:45 PM Abstract No. 266

Safety of radioembolization using glass microspheres for hepatocellular carcinoma in patients with prior biliary interventions
A. Noor1, A. Fischman1, R. Lookstein2, F. Nowakowski3, R. Patel4, V. Bishay5, M. Ranade6, E. Kim7, 1Icahn School of Medicine at Mount Sinai, New York, NY; 2Mount Sinai Hospital, New York, NY; 3Mount Sinai Medical Center, New York, NY; 4Icahn School of Medicine at Mount Sinai Hospital, New York, NY

Purpose: The purpose of this study is to examine safety of yttrium-90 radioembolization (RE) using glass microspheres in patients with prior biliary interventions resulting in biliary-enteric anastomosis; including prior liver transplants and ERCP biliary stent placement.

Materials: Retrospective single-center database review of all RE with glass microspheres (TherasPhere, BTG) performed from August 2007 to August 2017 revealed 18 cases (mean age: 62.3 ± 11.3, male: 66.1%) performed in patients with prior biliary intervention. Types included: liver transplant with biliary anastomosis (n = 8) prior ERCP deployed biliary stents (n = 10). An antibiotic prophylaxis protocol was used in all patients, which consisted of 1 preprocedural dose of piperacillin-tazobactam (3.375 g) and 7 days of postprocedure levofloxacin (500 mg daily). Patient demographics, clinical status, CT/MRI imaging, laboratory values and adverse events (AEs) were evaluated up to 3 months post treatment.

Results: The total of 18 patients had a technical success was 100% (18/18) with no AEs seen immediately post procedure. Clinical status was evaluated using the Eastern Cooperative Oncology Group status (ECOG 1, 55.5%) and Child-Pugh class (B, 61.1%), which showed no significant change in the 3 months following the RE (p>0.05). There was also no significant change in total bilirubin (+ 0.9 mg/dL, p < 0.05) to suggest postoperative biliary obstruction. Evaluation of imaging up to 3 months revealed no infectious AEs such as biloma, abscess or biliary sticture (0/18).

Conclusions: RE with glass microspheres in patients with prior biliary intervention appears safe and well tolerated with appropriate antibiotic prophylaxis.

3:54 PM Abstract No. 267

Assessment of patients with hepatocellular carcinoma: the independent roles of albumin and bilirubin
M. Antkowiak1, A. Gabr1, R. Ali2, R. Mora3, S. Mouli1, R. Lewandowski4, R. Salem5, A. Riaz5; 1Northwestern University, Forest Park, IL; 2Northwestern University, Chicago, IL; 3N/A, Chicago, IL; 4Northwestern University, Chicago, IL; 5Northwestern Medicine, Chicago, IL

Purpose: Child Pugh (CP) is used to assess liver function in patients with hepatocellular carcinoma (HCC). The albumin-bilirubin (ALBI) score uses only objective parameters to assess function. In this study, we assessed the independent roles of albumin and bilirubin as predictors of survival in HCC patients treated with yttrium-90 radioembolization (Y90).

Materials: With IRB approval, baseline albumin and bilirubin levels were collected from 1000 consecutive HCC patients who underwent Y90. Survival from first Y90 was assessed using Kaplan Meier analysis, with stratification by albumin and bilirubin, with subgroup analysis by Barcelona Center Liver Cancer (BCLC) and United Network for Organ Sharing (UNOS) staging. Cutoffs for albumin and bilirubin values were based on CP scores. Classes 1, 2 and 3 were for bilirubin and (less than 2, 2-3, and greater than 3) mg/dl and (0-3.5, 3.5-5.5, >5.5) g/dl for bilirubin and albumin, respectively. The independent impact of albumin and bilirubin on survival was assessed with Cox Proportional Hazards analysis.

Results: Using cutoffs determined by CP, 188 patients were albumin 1, 433 were albumin 2, and 379 were albumin 3. 837 were bilirubin 1, 111 were bilirubin 2, and 52 were bilirubin 3. Survival of the full patient cohort stratified by albumin showed median survival of albumin 1, 2 and 3 was 46.0 (30.3-not reached), 17.3 (15.1-21.4), and 9.3 (8.0-11.0) months respectively. Stratification by bilirubin revealed median survival of bilirubin 1, 2 and 3 was 15.7 (14.4-17.7), 17.7 (15.1-27.1), and 5.8 (4.4-14.8) months respectively. Survival of subgroups determined by BCLC or UNOS using CP cutoffs showed similar trends in survival between albumin and bilirubin stratification. Cox proportional hazards analysis showed hazard ratios of 0.53 (0.44-0.63) (p < 0.001) for albumin 1-2 and 0.22 (0.16-0.30) (p < 0.001) for albumin 2-3. Hazard ratios were 1.15 (0.86-1.53) (p = 0.341) for bilirubin 1-2 and 2.39 (1.66-3.42) (p < 0.001) for bilirubin 2-3.

Conclusions: Albumin is a better prognosticator of survival than bilirubin for HCC patients undergoing Y90. Albumin levels alone may be able to prognosticate survival. Further analyses are needed to validate this observation.

4:03 PM Abstract No. 268

Role of Y90 radioembolization in BCLC D patients
A. Gabr1, R. Ali2, R. Mora3, A. Al Asadi3, N. Abouchaleh4, L. Kulik5, S. Mouli1, A. Riaz6, R. Lewandowski4, R. Salem5; 1Northwestern University Feinberg School of Medicine, Chicago, IL; 2Northwestern University, Forest Park, IL; 3N/A, Chicago, IL; 4Northwestern University, Chicago, IL; 5Northwestern University, Feinberg School of Medicine, Chicago, IL; 6Northwestern Medicine, Chicago, IL

Purpose: Hepatocellular carcinoma (HCC) patients with end-stage liver disease [Child-Pugh (CP) class C] are considered as terminal stage BCLC D. The ability to treat HCC in BCLC D patients represents a challenge and concern for precipitating further decompensation and mortality. However, progression beyond Milan criteria may jeopardize liver transplantation (LT) candidacy.
In this study we show overall survival (OS) outcomes of BCLC D patients treated with Y90 radioembolization (Y90).

**Materials:** With IRB approval, we searched our prospectively acquired HCC database. Inclusion criteria included BCLC D patients who underwent Y90 between 2004 and 2017. Baseline tumor characteristics were evaluated. New laboratory toxicities at 1-month post Y90 were recorded. OS was estimated using Kaplan Meier method from date of Y90.

**Results:** 44 patients with HCC and CP C (BCLC D) received 53 Y90 treatments. 34 (77%) were male; mean (range) age was 62 (47-85) years. 23 (52%) had T1/T2 tumors, 4 (10%) had T3, 8 (20%) T4a, 9 (20%) T4b and 2 (5%) patients had metastases at baseline. Only 6 (14%) patients showed new grade 3/4 bilirubin toxicities while 3 (7%) exhibited new grade 3 albumin toxicity at 1-month after Y90. 14 (32%) patients underwent subsequent liver transplantation (LT). Median time to LT was 4.5 months. Of the 14 patients that received LT, 93% (13/14) had T2 tumors at time of Y90. Transplanted organs used included living donor LT (n=3), donor after cardiac death (DCD) or CDC high risk or both (n=4), split (n=1), donor after brain death (DBD) (n=5). HCC MELD upgrade was responsible 57% of allocated organ. 3 received LDLT and 3 were transplanted based on native MELD with a DBD (40, 40 and 25). TTT median OS1 was 14.8 months (95% CI: 4.8-21.3). Median OS for 14 patients who underwent OLT was not reached at 6-years, with 92% alive at year 5.

**Conclusions:** Recently, the BCLC algorithm has included transplantation for BCLC D disease. We demonstrate that long-term survival may be seen in select BCLC D patients treated with Y90.

**4:12 PM Abstract No. 269**

**Modern multidisciplinary management of hepatocellular carcinoma: deviation from BCLC guidelines does not alter survival**

D. Strom¹, A. Johnston², A. Gabr², R. Ali², A. Riaz⁴, R. Hickey⁶, R. Salem⁴, R. Lewandowski⁵, S. Mouli³; ¹Feinberg School of Medicine, Chicago, IL; ²Northwestern University Feinberg School of Medicine, Chicago, IL; ³Department of Surgery, Northwestern University, Forest Park, IL; ⁴Northwestern Medicine, Chicago, IL; ⁵Northwestern University, Chicago, IL

**Purpose:** The Barcelona Clinic Liver Cancer (BCLC) staging system is the most widely used hepatocellular carcinoma (HCC) guideline. However, the BCLC system is criticized for its limited applicability in many clinical scenarios. In this study, we compared treatment recommendations from our multidisciplinary team to those recommended by the BCLC stage for patients designated BCLC stage 0 through stage D.

**Materials:** With IRB approval, we included all new diagnoses of HCC discussed from 2010 to 2013 at our multidisciplinary tumor board, yielding 349 patients. The criteria for BCLC status at presentation were recorded. Tumor board recommendations for treatment, as well as BCLC recommendations were compared. Kaplan–Meier survival analyses were performed from the date of the first treatment, censored to curative treatment, to determine survival based on BCLC stage. The log-rank test was used to compare survival rates, with a P<0.05 considered significant.

**Results:** Of the 349 treatment-naïve patients 22 patients were BCLC 0, 153 were BCLC A, 31 were BCLC B, 97 were BCLC C, and 46 were BCLC D. Following multidisciplinary tumor board discussion, 79.9% (n = 279) received treatment recommendations discordant from BCLC recommendations. Intra-arterial therapy (chemoembolization or radioembolization) was used in 257 (73.6%) patients, discordant from BCLC recommendations. There was no significant difference in survival between patients who received BCLC treatment recommendations and those who did not (median survival 23.5 mos vs 24.2 mos, respectively, p = 0.21). Additionally, when stratified by BCLC stage, there were no significant differences in survival between those who followed BCLC treatment recommendations, and those who did not (p = 0.12).

**Conclusions:** Determining HCC treatment requires a multidisciplinary approach. In this analysis of treatment naïve HCC, deviation from BCLC recommendations yielded no significant difference in overall survival, even when stratified by BCLC stage. As part of individualization of patient care, primary treatments often deviate from BCLC recommendations due to unique clinical scenarios not captured by BCLC. This analysis supports the concepts of individualized patient care.

**4:21 PM Abstract No. 270**

**Iatrogenic celiac axis and hepatic artery dissections during intra-arterial regional tumor therapies: a 16-year retrospective review**

E. Alexander¹, G. Nadolski¹, M. Soulen⁷, S. Stavropoulos⁵, S. Hunt⁴, T. Gade⁵, M. Itkin⁶, S. Shamimi-Noori²; ¹University of Pennsylvania, Philadelphia, PA; ²University of Pennsylvania, Lafayette Hill, PA; ³University of Pennsylvania, Bryn Mawr, PA; ⁴Hospital of the University of Pennsylvania, Philadelphia, PA; ⁵Hospital of the University of Pennsylvania, Philadelphia, PA; ⁶Penn Medicine, Bala Cynwyd, PA; ⁷Hospital of the University of Pennsylvania, Philadelphia, PA

**Purpose:** Retrospectively identify the incidence and outcome of iatrogenic celiac axis and hepatic artery dissections during transarterial embolization of liver tumors, including chemoembolization, radioembolization (TARE), and pre-TARE scintigraphic mapping.

**Materials:** Included were 2214 patients with 3729 treatment encounters from January 2001 to July 2017. The institution’s QA database, EMR, and PACS were reviewed to identify incidence of dissection during transarterial oncology procedures, to evaluate immediate management of dissections, assess patency of the arteries after dissection, and ability to administer therapy.

**Results:** Among the 3729 arteriograms performed, iatrogenic dissections of celiac axis or hepatic artery occurred in 39 procedures (1.0%), affecting 38 patients. The incidence of flow limiting dissections was 0.3% (12/3729) and non-flow limiting dissections was 0.7% (27/3729). Ten of the 39 dissections (6 flow limiting, 4 non-flow limiting) were treated intraoperatively with: nitroglycerin (n = 3), heparin (n = 3), heparin and nitroglycerin (n = 2), heparin and PTA (n = 1), and heparin, nitroglycerin and PTA (n = 1). Of the treated cases, 40% (4/10) of therapies were completed on the same day. Overall, 69% (27/39) of procedures were completed the same day as the dissection; either the dissection was non-flow limiting (n = 23), treatment was delivered via
alternate artery (n = 3), or the true lumen was traversed (n = 1). In the remaining 12 cases, 7 patients subsequently underwent successful embolic dissection at a median of 67 days after the procedure. Follow-up imaging was obtained in 25 of the 39 cases at a median time of 56 days; complete resolution was seen in 14 cases, near complete resolution (<30% luminal narrowing) in 3, unchanged appearance of a non-flow limiting dissection in 4, progressive luminal narrowing in 3, and complete occlusion in 1 case.

Conclusions: Iatrogenic celiac axis or hepatic artery dissections occur rarely during tumor embolization. Even after dissection, 69% of cases were still completed on the same date and another 18% were completed during follow-up procedure. Thus, these rare injuries have little impact on the overall treatment of patients.

Scientific Session 28
Chemoembolization: Liver 2

Tuesday, March 20, 2018
3:00 PM–4:30 PM
Room: 407

3:00 PM Abstract No. 271

Prospective phase II Study of chemoembolization with doxorubicin-eluting microspheres for liver transplantation candidates with hepatocellular carcinoma and marginal hepatic reserve

N. Fidelman1, C. Johanson2, M. Kohi, K. Kolli2, R. Kohlbrenner2, E. Lehrman2, A. Taylor2, R. Kelley2, F. Yao2, J. Roberts2, R. Kerlan2; 1University Of California San Francisco, San Francisco, CA; 2University of California San Francisco, San Francisco, CA;

Purpose: To determine which imaging predictors are associated with treatment response of drug-eluting bead transarterial chemoembolization (DEB-TACE) in patients with advanced hepatocellular carcinoma (HCC).

Materials: Seventeen adult liver transplantation candidates (median age 66, range 58-73; 13 men) with HCC diagnosed according to AASLD guideline (UNOS T1 n = 4, T2 n = 8, T3 n = 5) were treated with DEB-TACE (up to 2 vials of 100-300 micron LC-Bead loaded with 50 mg of doxorubicin per vial) as a part of Stage 1 of a prospective single-institution phase II study between January and August of 2015. All patients had marginal hepatic reserve based on the setting of metastatic HCC (n = 4), or in the setting of locally advanced HCC (n = 2). One death occurred 18 months following DEB-TACE and may have been precipitated by the procedure.

Conclusions: DEB-TACE is effective for treatment of early and intermediate-stage HCC for patients with marginal hepatic reserve. However, further decline in liver function is common. Therefore, only listed patients with marginal hepatic reserve should be offered DEB-TACE as a “bridge” to transplantation.

3:09 PM Abstract No. 272

Imaging predictors for tumor response to drug-eluting bead transarterial chemoembolization in patients with advanced hepatocellular carcinoma

K. Chang1, Z. Hwang2, Y. Shih3, H. Lin1, H. Fan1, W. Chang1, Y. Chou4, H. Hsu1; 1Tri-Service General Hospital and National Defense Medical Center, Taipei, Neihu Dist.; 2Van Fang Hospital and Taipei Medical University, Taipei, Wenshan Dist.; 3Tri-Service General Hospital and National Defense Medical Center, Taipei, Neihu Dist.; 4National Defense Medical Center, Taipei, Neihu Dist.

Purpose: To determine which imaging predictors are associated with treatment response of drug-eluting bead transarterial chemoembolization (DEB-TACE) in patients with advanced hepatocellular carcinoma (HCC).

Materials: We performed a retrospective review of 177 HCC patients treated with DEB-TACE from October 2013 to December 2016, and 55 (31%) were Barcelona Clinic Liver Cancer stage C, defined as advanced HCCs. Of these advanced HCCs, we further excluded patients who received prior locoregional therapy (n = 8), systemic therapy (n = 2) and loss of follow-up (n = 1). Demographics data, laboratory results, tumor characteristics (size, number), imaging features at the baseline and at 3-month, 6-month post-TACE, and angiographic features were recorded. HCC tumor response to DEB-TACE was quantified via the modified Response Evaluation Criteria in Solid Tumors criteria. HCC lesions were classified into responder (complete and partial response) and non-responder (stable condition and disease progression) groups. Univariate and multivariable analyses were then constructed. Kappa coefficient of agreement was used to assess interobserver variability.

Results: A total of 71 HCCs in 44 patients received DEB-TACE, including responder (n = 48, 67.6%) and non-responder (n = 23, 32.4%). Multivariate analysis demonstrated that responder was associated with strong tumor enhancement (odds ratio
3:18 PM Abstract No. 273

AFP-negative hepatocellular carcinoma identifies tumors with better post-TACE necrosis rates at liver explant: evaluation of 83 patients in a 7-year transplant cohort

T. Sandow1, J. Pavlus1, T. Caridi1, G. Lynskey1, D. Buckley3, J. Cardella1, D. Field1, E. Cohen1, J. Spies1, A. Kim1; 1Medstar Georgetown University Hospital, Washington, DC

Purpose: Alpha-fetoprotein (AFP) levels have been used in the diagnosis and surveillance of hepatocellular carcinoma (HCC) as well as posttreatment response. However, non-AFP shedding tumors could reflect an alternate form of HCC that warrants different understanding and treatment consideration. This study compares AFP-shedding tumors to AFP-negative tumors in patients who were successfully bridged to transplant with transarterial chemoembolization.

Materials: A single-center, retrospective analysis was performed on all patients who were treated for HCC with conventional TACE (cTACE) or TACE with drug-eluting beads (DEB-TACE) from 10/16/2009 to 8/31/2016 who had serum AFP values available prior to treatment (n = 83). Treatment response was based on modified RECIST imaging criteria. The explant specimen of each patient was also evaluated for tumor grade, necrosis, lymphovascular invasion (LVI), and satellite nodules (SN). AFP-shedding (>20ng/mL) and AFP-negative tumors (≤20ng/mL) were analyzed regarding treatment response, explant findings, and posttransplant recurrence.

Results: AFP-negative tumors were identified in 45 patients, while AFP-shedding tumors were noted in 39 patients. Similar treatment types (p = 0.19) and treatment cycles (p = 0.70) were noted between the two groups. Lesion size (p = 0.52), lesion count (p = 0.67), initial treatment response (p = 0.53), and final treatment response prior to transplant (p = 0.84) were not significantly associated with AFP categorization. However, AFP-negative tumors that were treated with chemoembolization demonstrated higher degrees of necrosis at liver explant (p = 0.039). Complete necrosis was seen in 38% of AFP-negative tumors vs 15% of AFP-shedding tumors (p = 0.019). Significant necrosis (>80%) was seen in 62% of AFP-negative tumors vs 33% of AFP-shedding tumors (p = 0.001). Additionally, LVI was more likely to be associated with AFP-shedding tumors vs AFP-negative tumors (18% vs 5%, p = 0.05). Posttransplant recurrence was not significantly associated with AFP categorization (p = 0.12).

Conclusions: AFP-negative tumors highlight favorable explant pathology in patients with HCC that were bridged to transplant with chemoembolization.

3:27 PM Abstract No. 274

A prospective study of lung shunt fraction as a determinant of DEB-TACE response and metastasis and determinants of lung shunt fraction

S. Arndt1, T. Sandow1, D. Kay1, D. DeVun1, P. Gulotta2, D. Kirsch2, V. Ramalingam1, K. Nunez1, H. Bohorquez1, A. Cohen1, P. Thevenot1, J. Gimenez1; 1Ochsner Clinic Foundation, New Orleans, LA; 2Ochsner Clinic Foundation, Jefferson, LA; 3Ochsner Clinic Foundation, Baton Rouge, LA

Purpose: To evaluate the role of lung shunt fraction (LSF) as a predictor of treatment response to drug-eluting bead TACE (DEB-TACE) and metastasis, as well as to assess predictors of lung shunt fraction in a prospective single-center trial. Previous work identified LSF associations to response, survival, and vascularity1–3 in HCC and non-HCC liver cancer for radioembolization, but LSF has not been evaluated for DEB-TACE.

Materials: Prospective evaluation of locoregional therapy naive HCC patients evaluated with macro aggregated albumin to assess lung shunt fraction prior to initial DEB-TACE treatment. Patients then underwent immediate DEB-TACE. Treatment response was evaluated with one-month follow-up CT or MRI and scored via blinded evaluator on mRECIST and EASL criteria. LSF effect on treatment response was evaluated in univariate and multivariate analysis, with other variables of interest including absolute lymphocyte count, tumor size, and prior direct acting antiviral therapy. To assess possible predictors of LSF, effect screening was used to identify candidate variables from among 35 possible categories and the top 5 were evaluated in multivariate analysis.

Results: 23 patients have been enrolled, noting ongoing enrollment and follow-up, and for patients with follow-up imaging exams average LSF was 6.87% ± 2.35%. LSF is significantly associated with mRECIST (p = 0.020) and EASL (p = 0.0143) treatment response criteria. LSF was also associated with dichotomized (CR or PR vs SD or DP) mRECIST (p = 0.0072) and EASL (p = 0.0036). No variables were significantly associated with LSF. Variables selected through effect screening included longest tumor dimension, 3rd tumor dimension, eosinophil count, albumin, and INR. The single case of metastasis was above the preestablished high risk value for LSF; however, given limited follow-up, further evaluation of the time course of disease is needed.

Conclusions: Lung shunt fraction is an important biomarker with prognostic value in the treatment of patients with HCC, which is significantly associated with treatment response. This implies a continued and expanded role for LSF in preprocedural evaluation.
3:36 PM Abstract No. 275

FEATURED ABSTRACT
EpCAM-positive circulating tumor cells independently predict poor outcomes of transcatheter arterial chemoembolization in patients with unresectable hepatocellular carcinoma

J. Shen¹, W. Wang¹, X. Zhu¹, C. Ni²; ¹Department of Interventional Radiology, First Affiliated Hospital of Soochow University, Suzhou, Jiangsu; ²the first affiliate hospital of soochow university, suzhou, AK

Purpose: To assess the role of epithelial cell adhesion molecule (EpCAM)-positive circulating tumor cell (CTC) count in predicting outcomes of transcatheter arterial chemoembolization (TACE) in patients with unresectable hepatocellular carcinoma (HCC).

Materials: EpCAM-positive CTC counts were prospectively determined in peripheral blood of 97 patients with unresectable HCC treated with TACE, using CellSearch system. The impact of each cutoff point (each CTC value) on overall survival (OS) was evaluated by the univariate Cox regression analysis. Based on the hazard ratio (HR), the patients were divided into 3 groups: low risk (CTC = 0 and 1), moderate risk (CTC = 2-5) and high risk (CTC ≥ 6) groups. Cox proportional hazards model was used to assess the correlation of CTC counts with outcomes.

Results: Eighty-nine patients were enrolled in this study according to patient-selection criteria. The low risk group was used as the control group for univariate Cox analysis. Mortality risk in the high risk and moderate risk groups was 4.164 (95% Confidence Interval [CI], 2.042-8.492, P = 0.000) and 1.695 (95%CI, 0.883-3.253, P = 0.113) times higher, respectively, than that in the low-risk group. On multivariate Cox regression analysis, CTC count was found to be an independent predictor of OS (P = 0.049) and progression-free survival (PFS) (P = 0.007) in patients treated with TACE. After adjustment for confounding factors, the mortality risk in the high risk and moderate risk groups was 2.819 times (95%CI, 1.218-6.526, P = 0.016) and 1.301 times (95%CI, 0.630-2.685, P = 0.477) higher than that in the low risk group.

Conclusions: EpCAM-positive CTC count can independently predict poor outcomes of TACE in patients with unresectable HCC.

3:45 PM Abstract No. 276

Can pretransplant TACE improve overall posttransplant survival for patients with hepatocellular carcinoma?

J. Buethe¹, J. Werner¹, R. Liddell¹, C. Frangakis¹, J. Ruck³, K. Hong³, B. Philosophe¹, A. Cameron¹, B. Saberi¹, A. Gurakar¹, C. Georgiades³; ¹Johns Hopkins Hospital, Baltimore, MD; ²Johns Hopkins Hospital, Woodstock, MD; ³Johns Hopkins University, Baltimore, MD

Purpose: To evaluate the effect of pretransplant transarterial chemoembolization (TACE) on the post-transplant survival of patients with cirrhosis and hepatocellular carcinoma (HCC) undergoing liver transplantation.

Materials: A retrospective review of all patients with cirrhosis and HCC who underwent liver transplantation from 2/2005 through 7/2015 at a single tertiary care hospital (n = 155; age: 59 ± 4y, male: 76%) was performed. Survival rates were compared using 2-sample t-tests and multivariate Cox regression. Patients were stratified according to the following variables pre- and posttransplantation (explant): tumor size, alpha-fetoprotein (AFP) level, liver function tests, and the Model for End-stage Liver Disease (MELD) score.

Results: Of 155 patients who underwent liver transplantation for HCC, 136 (88%) met Milan criteria at the time of presentation and 19 (12%) were downstaged to the Milan criteria before transplantation. Eighty-seven of 155 (56%) underwent pretransplant TACE (51% conventional TACE, 49% drug-eluting beads TACE). One-, 3-, and 5-year survival rates, respectively, were 84%, 71%, and 63% for all patients; 91%, 78%, and 73% for TACE patients; and 76%, 63%, and 54% for non-TACE patients. The patients treated with TACE prior to transplant had a 44% reduction in posttransplant mortality (Hazard ratio [HR]: 0.56, P = 0.04). Poor overall survival was seen in patients with the largest tumor size >3 cm (HR: 1.5, P = 0.15); pretransplant AFP >659ng/mL (HR: 2.9, P = 0.006); higher MELD score (HR = 1.53, P < 0.001). Pretransplant Milan criteria, liver function test values, and European Association for the Study of the Liver imaging response were not correlated with survival.

Conclusions: Pretransplant TACE may be associated with better overall survival in patients who undergo a liver transplantation for cirrhosis and HCC. In the present series, there was no significant difference in the post-transplant survival rate between the patients who were within Milan criteria initially and those who were downstaged into Milan criteria after TACE.

3:54 PM Abstract No. 278

Predicting recurrence prior to transplant: the response of hepatocellular carcinoma to chemoembolization in a 12-year transplant cohort

T. Sandow¹, J. Pavlus¹, T. Caridi¹, G. Lynskey¹, D. Buckley¹, D. Field¹, J. Cardella¹, E. Cohen¹, J. Spies¹, A. Kim¹; ¹Medstar Georgetown University Hospital, Washington, DC

Purpose: Using transarterial chemoembolization (TACE) to bridge patients with hepatocellular carcinoma (HCC) to liver transplant, this study assesses imaging response characteristics to TACE and the risk of post-transplant recurrence.

Materials: Retrospective analysis was performed on all patients who were treated for HCC with conventional TACE (cTACE) or TACE with drug-eluting beads (DEB-TACE) from 2/9/2005 to 2/6/2017 and subsequently transplanted (n = 142). Treatment response was based on modified RECIST imaging criteria. The most immediate posttreatment imaging response prior to transplantation was compared with tumor biology and recurrence. Of the 142 patients followed after transplant (mean time of follow-up,
TUESDAY: \textit{Scienti}

\textbf{Results:} Recurrence occurred in 9 patients (mean time from transplant, 526 days). Poor treatment response (SD/DP) accounted for 67\% (6/9) of cases of recurrence and was present in 18\% (23/125) of patients prior to transplant (p = 0.0008). When mRECIST categories are further stratified, recurrence was seen in 1.4\% (1/71) CR vs 6.5\% (2/31) PR vs 18.8\% (3/16) SD vs 43\% (3/7) DP prior to transplant (p = 0.0025). Mixed HCC/ cholangiocarcinoma tumors at explant (p = 0.004), higher tumor grade at explant (p = 0.04), and lymphovascular invasion at explant (p = 0.007) were also associated with increased incidence of posttransplant recurrence. While a trend in increased pretreatment tumor size and posttransplant recurrence was identified (3.3 cm vs 2.7 cm, p = 0.09), no additional pretreatment variable was identified to suggest an association with posttransplant recurrence in patients who were treated with TACE prior to transplant.

\textbf{Conclusions:} Many models have recently been proposed to help identify the risk of posttransplant recurrence in patients with HCC. However, these models are limited by their posttransplant predictive ability. TACE response prior to transplant highlights patients at risk for posttransplant recurrence and could play an important role in liver transplant allocation.

\section*{4:03 PM \textbf{Abstract No. 279}}

\textbf{Additional drug-eluting beads transcatheter arterial embolization (dTACE) as salvage therapy in advanced hepatocellular carcinoma with portal vein thrombosis refractory to conventional TACE (cTACE): an initial study of 64 patients}

W. Fan\textsuperscript{1}, J. Li\textsuperscript{2}; \textsuperscript{1}The First Affiliated Hospital of Sun Yat-Sen University, Guangzhou, Guangdong; \textsuperscript{2}The First Affiliated Hospital of Sun Yat-Sen University, Guangzhou, Guangzhou Guangdong

\textbf{Purpose:} To evaluate the utility of additional drug-eluting beads (DEB) transcatheter arterial embolization (dTACE) as salvage therapy in cases of advanced HCC with portal vein thrombosis (PVTT) refractory to conventional TACE (cTACE).

\textbf{Materials:} A retrospective study of 64 advanced HCC patients with PVTT refractory to cTACE were enrolled to undergo dTACE from January 2014 to January 2017. dTACE was performed using 50–100 um superabsorbent polymer microspheres loaded with doxorubicin together with hepatic arterial infusion of 60 mg doxorubicin per patient. Tumor responses and overall survival were evaluated were the major endpoint. Adverse event was the second endpoint.

\textbf{Results:} The median number of dTACE treatment sessions was 1.7 (range, 1–5), and the mean follow-up duration was 5.73 months (range, 3 to 22 months). After 3 months, 3 (4.7\%) patients achieved complete response, 36(56.2\%) had partial response, 11 (17.2\%) had stable disease, and 14 (21.9\%) had progressive disease. The median overall survival and time to treatment failure after initial dTACE were 11.5 and 6.7 months, respectively. Multiple tumors, tumor size $\geq$10 cm, and main PVTT were independent unfavorable prognostic factors for OS after rupture, with hazard ratios of 2.01 (95\% confidence interval [CI] 95\% CI 1.51–2.74; P = 0.004), 1.97 (95\% CI 1.45–3.02; P < 0.001), and 7.33 (95\% CI 4.58–21.61; P < 0.001), respectively.

\textbf{Conclusions:} dTACE is a safe, well-tolerated, and efficacious treatment strategy for salvage TACE with drug-eluting microspheres in advanced HCC patients with PVTT refractory to cTACE.

\section*{4:12 PM \textbf{Abstract No. 280}}

\textbf{Infectious complications following transarterial chemoembolization in hepatocellular carcinoma patients with leukopenia and neutropenia}

A. True-Yasaki\textsuperscript{1}, J. Phuong\textsuperscript{2}, D. McCoy\textsuperscript{3}, R. Kerlan\textsuperscript{1}, M. Kohi\textsuperscript{1}, R. Kohlbrenner\textsuperscript{1}, K. Kolli\textsuperscript{1}, E. Lehrman\textsuperscript{1}, A. Taylor\textsuperscript{1}, F. Yao\textsuperscript{3}, N. Fidelman\textsuperscript{1}; \textsuperscript{1}University of California, San Francisco, San Francisco, CA; \textsuperscript{2}University of California, Davis, Sacramento, CA; \textsuperscript{3}UCSF/ZSFG, San Francisco, CA

\textbf{Purpose:} Patients with hepatocellular carcinoma (HCC) often have leukopenia or neutropenia at the time of transarterial chemoembolization (TACE) due to underlying cirrhosis and portal hypertension. The purpose of this study was to assess for an association between leukopenia or neutropenia and development of an infectious complication after TACE.

\textbf{Materials:} The charts of 824 consecutive patients who underwent 1962 TACE procedures (1357 conventional TACE and 605 drug-eluting bead TACE) at UCSF from January 2008 to January 2017 were retrospectively reviewed. Data regarding pretreatment white blood cell count (WBC) and absolute neutrophil count (ANC) were collected. The main outcome was infectious complication within 90 days after TACE. Univariate logistic and linear models were used to identify confounders. Two mixed effects logistic models were constructed to identify the association of WBC and ANC with odds of infection, adjusting for confounders.

\textbf{Results:} Infections developed following 102 TACE procedures (5\%) in 94 patients (11\%). Infectious complications included pneumonia (27), urinary tract infection (23), spontaneous bacterial peritonitis (10), sepsis (9), bacteremia (6), C. difficile colitis (5), cholecystitis (4), liver abscess (3), and cholangitis (1). A one-standard deviation (SD) increase in WBC was associated with a 2.34 increased odds of infection, borderline significant at p = 0.12. Conversely, a one-SD increase in ANC was associated with a 39\% reduced likelihood of infection, borderline significant at p = 0.13. Multivariate analysis showed that a one-SD increase in albumin was associated with a 42\% decrease in the likelihood of infection while controlling for other factors (p = 0.05). Conversely, an increase from no ascites to mild ascites was associated with 2.77 increased odds of infection while controlling for other factors (p = 0.05).

\textbf{Conclusions:} Pretreatment leukopenia and neutropenia did not show a statistically significant association with infectious complications after TACE. However, ascites and hypoalbuminemia were associated with an increase in infections. This suggests that hepatic reserve may more accurately predict risk of infectious complications after TACE.
Long-term outcomes in superselective transarterial chemoembolization using lipiodol with 3D: safety margin versus radiofrequency ablation for solitary small hepatocellular carcinoma

T. Matsumoto¹, H. Nishiofuji¹, T. Tanaka¹, T. Sato¹, T. Masada¹, S. Tatsumoto¹, K. Kichikawa¹; ¹Nara Medical University, Kashihara, Nara, Japan

Purpose: To compare tumor control rate and survival duration between superselective transarterial chemoembolization using lipiodol (cTACE) and radiofrequency ablation (RFA) as an initial treatment of solitary small HCC.

Materials: In 798 consecutive patients with newly diagnosed HCC between 2007 and 2015, 130 patients with solitary small HCC (mean 1.7 cm, 0.5–3.0 cm in diameter) who underwent superselective cTACE alone (62 patients) or RFA alone (68 patients) were retrospectively analyzed. 3D-safety margin was obtained in 45 patients (72.3%) in cTACE. Local progression-free survival (PFS) and overall survival (OS) were calculated by Kaplan-Meier method.

Results: Median OS/local PFS of cTACE with and without 3D-safety margin were 86.0/51.0 months and 89.3/49.8 months in RFA. There were no significant differences in OS and PFS between cTACE with margin and RFA, although those of cTACE without margin showed significantly shorter survival. The 1-, 3-, 5-year rates of OS/local PFS of cTACE with margin were 97.8/88.8%, 88.3/66.0%, and 69.6/44.8%, respectively, while those of RFA were 97.1/88.1%, 89.3/66.0%, and 82.6/57.9% and 58.6/44.8%, respectively.

Conclusions: Superselective cTACE obtaining 3D-safety margin demonstrated a high tumor control rate with encouraging long survival duration, which could produce similar outcomes to RFA, in patients with initial solitary small HCC.

Scientific Session 29
Portal Hypertension

Tuesday, March 20, 2018
3:00 PM–4:30 PM
Room: 409A

Abstract No. 282

Transjugular intrahepatic portosystemic shunting reduces paracentesis rates in patients with cirrhosis and ascites: a population-based analysis

A. Niekamp¹, M. Khan², T. Daileeda³, J. Kuban³, S. Yevich³, E. Miller³, A. Tam³, S. Gupta², S. Sheth³, R. Sheth²; ¹The University of Texas at Houston, Houston, TX; ²MD Anderson Cancer Center, Houston, TX; ³University of Texas McGovern School of Medicine, Houston, TX; ⁴UT/MD Anderson, Houston, TX

Purpose: Ascites is a leading cause of morbidity and mortality in patients with cirrhosis. Transjugular intrahepatic portosystemic shunting (TIPS) has been shown to improve refractory ascites in cirrhotic patients based on a series of clinical trials. The purpose of this study was to conduct a population-level analysis of the utilization and impact of TIPS in cirrhotic patients with ascites.

Materials: Using administrative data from all inpatient and outpatient hospital encounters in California (2009-2011), patients with cirrhosis complicated by ascites were identified. The utilization of TIPS and its influence on ascites management was evaluated in this patient population.

Results: A total of 180,286 patients with cirrhosis were identified, of whom 36,751 patients (20.3%) were noted to have non-malignant/non-cardiogenic ascites. Within this population of cirrhotic patients with ascites, 1,166 TIPS were performed in 1,150 patients (3.1%). There was a greater baseline rate of paracenteses for the TIPS vs non-TIPS patients (mean 1.44 vs 1.05 procedures/month, P < 0.001). There was a significant decrease in the frequency of paracenteses for patients following TIPS (0.4 procedures per month, P < 0.001). There was also a significant decrease in hospital visits for peritonitis following TIPS (P = 0.02). There was a non-significant trend towards increased hepatic encephalopathy following TIPS (P = 0.08).

Conclusions: TIPS is associated with reduced frequency and complications of paracenteses for the management of refractory ascites in patients with cirrhosis. TIPS has a low utilization rate in this population, but the benefits of the procedure should be weighed with the risks of hepatic encephalopathy.

TIPS No TIPS P Value

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>1150</th>
<th>35601</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (% female)</td>
<td>56</td>
<td>57</td>
</tr>
<tr>
<td>Comorbidities (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coagulopathy</td>
<td>86.3</td>
<td>63.3</td>
</tr>
<tr>
<td>Obesity</td>
<td>30.5</td>
<td>18.5</td>
</tr>
<tr>
<td>Renal failure</td>
<td>46.7</td>
<td>35.3</td>
</tr>
<tr>
<td>CHF</td>
<td>15.7</td>
<td>21.3</td>
</tr>
<tr>
<td>Viral hepatitis</td>
<td>53.9</td>
<td>50.0</td>
</tr>
<tr>
<td>History of malignancy (%)</td>
<td>0.3</td>
<td>5.7</td>
</tr>
<tr>
<td>Baseline history of hepatic encephalopathy (%)</td>
<td>62.2</td>
<td>32.1</td>
</tr>
<tr>
<td>Baseline history of peritonitis (%)</td>
<td>70.2</td>
<td>15.9</td>
</tr>
<tr>
<td>Baseline paracentesis rate (procedure/month)</td>
<td>1.44</td>
<td>1.05</td>
</tr>
</tbody>
</table>
New York, NY; ^2Mallinckrodt Institute of Radiology, St. Louis, MO; ^3Washington University School of Medicine, St. Louis, MO

**Purpose:** To compare procedure characteristics and outcomes when TIPS is performed under intravascular ultrasound guidance (iTIPS) compared to conventional fluoroscopic guidance (cTIPS).

**Materials:** A retrospective propensity-matched study of 240 patients treated with TIPS procedures from January 2014 to March 2017 at a single academic medical center was performed. A propensity score matched several key factors including: age, race, gender, etiology of liver disease, indication for TIPS, MELD score, portal vein patency, and operator experience. Propensity matching yielded 30 pairs of patients when operator experience was included and 20 pairs when included. Procedure characteristics and postprocedure outcomes were compared between propensity-matched groups including: time to access portal vein, total procedure time, technical success, radiation dose, contrast volume, complication rate, 30 day mortality, and revision rate within 3 months.

**Results:** When propensity matching did not include operator experience, radiation dose measured in reference air kerma was significantly decreased from 875.3 mGy in the cTIPS group to 457.4 mGy in the iTIPS group (p = 0.039). Contrast volume was also significantly decreased from 141 mL in the cTIPS group to 103 mL in the iTIPS group (p = 0.005). There was no difference in time to access the portal vein, total procedure time, and procedure outcomes between the two groups. All procedures were technically successful with no mortalities within 30 days. 2/30 iTIPS (6.7%) and 3/30 cTIPS (10%) cases required revision rate within 3 months.

**Conclusions:** In this propensity-matched population, iTIPS resulted in significantly reduced radiation dose and decreased contrast volume. However, at a high-volume TIPS center, there was no difference in total procedure time or overall outcomes.

**3:18 PM Abstract No. 284**

**DIPS versus IVUS-guided TIPS: procedural metrics and intervention-free patency**

S. Kao^1, D. Scipio^2, J. Park^3, E. Lee^1, J. Minocha^2, K. Narsinh^4, H. Aryafar^2; ^1UCLA Medical Center, Los Angeles, CA; ^2UC San Diego Health, San Diego, CA; ^3West Los Angeles VA Medical Center, Los Angeles, CA; ^4University of Pennsylvania, Philadelphia, PA

**Purpose:** Direct intrahepatic portosystemic shunting (DIPS) can be performed from the inferior vena cava (IVC) to portal vein using intravascular ultrasound (IVUS) guidance in the setting of hepatic or portal venous thrombosis or variant anatomy. While transjugular portal venous access has been historically performed solely under fluoroscopy, IVUS is increasingly used to guide portal vein access during TIPS. We sought to compare procedural metrics and intervention-free shunt patency in DIPS and IVUS-guided TIPS.

**Materials:** We retrospectively reviewed 24 DIPS and 102 TIPS cases, 46 of which involved IVUS guidance, performed between 2008 and 2017. Patient demographics, clinical history and indication for portosystemic shunting were reviewed. Procedural metrics such as the number of intrahepatic needle passes to obtain portosystemic access, contrast volume, air kerma radiation dose, fluoroscopy and procedure time were recorded. Follow up imaging and clinical notes were examined to determine intervention-free shunt patency. Statistical analysis was performed with the Exact, Rank-Sum, and Log-Rank Tests.

**Results:** Patient demographics, cause and severity of liver disease were similar between groups. DIPS patients were more likely to have undergone shunting for Budd-Chiari and hepatic/portal venous thrombosis and less likely for refractory ascites (P < 0.01). DIPS was associated with greater contrast volume (103 vs 57 mL P < 0.01), fluoroscopy time (27 vs 19 min P < 0.01), air kerma (7221 vs 174 mGy P < 0.01) and procedure time (124 vs 85 min P < 0.01) compared to IVUS-guided TIPS. There was no difference in number of needle passes (3 vs 2 P = 0.28) or intervention-free shunt patency (P = 0.55) with a 1-year patency probability of 0.80 and 0.87 in DIPS and IVUS-guided TIPS, respectively.

**Conclusions:** DIPS is equivalent to TIPS in terms of intervention-free shunt patency and the number of needle passes needed to gain portal venous access. DIPS was associated with greater contrast volume use, fluoroscopy time, radiation dose and procedure time when compared to IVUS-guided TIPS.

**3:27 PM Abstract No. 285**

**Outcomes of transjugular intrahepatic portosystemic shunt using 12-mm-diameter polytetrafluoroethylene-covered stents in cirrhotic patients with portal hypertension and variceal bleeding**

A. Gunn^1, K. Mahmoud^1, S. Kim^1, B. Heeke^1, N. Ertel^1, S. Moawad^1, M. Massoud^1, S. Saddekni^1, A Abdel Aal^1; ^1University of Alabama at Birmingham (UAB), Birmingham, AL

**Purpose:** The objective of this study is to evaluate the efficacy, complications and survival outcomes of transjugular intrahepatic portosystemic shunt (TIPS) creation performed by using a 12-mm-diameter polytetrafluoroethylene (PTFE)-covered stent in cirrhotic patients with portal hypertension and variceal bleeding.

**Materials:** We retrospectively reviewed the medical records of 173 patients who underwent transjugular intrahepatic portosystemic shunt (TIPS) for bleeding varices from January 2004 to February 2017, using 12-mm Viatorr (Gore, Newark, DE) stent.
Patients’ demographics, comorbidities, Model for End-stage Liver Disease (MELD) score, occurrence of rebleeding, incidence or worsening of hepatic encephalopathy (HE) and the need for TIPS revision were recorded. Survival outcomes were calculated.

**Results:** The study included 113 (65.3%) males and 60 (34.7%) females with a mean age of 56.5 years (SD = 10.6 years). Cirrhosis was caused by alcohol, HCV and NASH in 36.4%, 32.4% and 27.7% of the patients. The mean Charlson Index for patients’ comorbidities was 3.8 (SD = 1.0). MELD score increased significantly after TIPS from a mean of 12.1 to 15.5 (p < 0.0001). Rebleeding rate after successful TIPS was 3.96%, 11.95% and 12.94% at 3, 6 and 12 months respectively. Before TIPS, HE was seen in 11.2% of the patients. After TIPS, HE was seen in 29.2%, 33.3% and 41.9% at 3, 6 and 12 months respectively. Medically uncontrolled HE was seen in 27.8% of patients after TIPS. TIPS revisions were performed in 2.9%, 6.4% and 6.9% of the patients at 3, 6 and 12 months following TIPS, respectively. The overall survival at 3, 6, 12 and 60 months was 80.9% 80.1%, 74.2% and 51.6% respectively.

**Conclusions:** The 12-mm-diameter PTFE-covered stent used in the creation of TIPS in cirrhotic patients with portal hypertension and variceal bleeding appears more efficacious and without increased complication rate compared to published literature on the 8 and 10 mm diameter similar stents. Survival outcomes also appear acceptable with 51.6% survival at 5 years.

### 3:36 PM  
**Abstract No. 286**

**Transjugular intrahepatic portosystemic shunt dysfunction: quantitative assessment of perfusion changes using 2D-perfusion angiography following shunt revision**

S. Maschke1, T. Werncke2, J. Renne3, S. Marquardt4, F. Wacker5, B. Meyer6, J. Hinrichs7; 1MH Hannover, Hannover, Germany; 2Dep. of diagnostic and interventional Radiology, Hannover, DC; 3N/A, Hannover, Germany; 4Hannover Medical School, Hannover, Germany; 5Dept. of Diagnostic and Interventional Radiology, Hannover, Germany; 6Hanover Medical School, Hannover, Germany; 7Dep. for diagnostic and interventional Radiology, Hannover, Germany

**Purpose:** To analyze the feasibility of 2D-perfusion angiography (2D-PA) in quantifying perfusion changes pre- and post-transjugular intrahepatic portosystemic shunt (TIPS) revision.

**Materials:** Fifteen patients (54 ± 14 years, 8 women) undergoing TIPS revision were included in this study. To quantify perfusion changes caused by TIPS revision using 2D-PA, acquired DSA series were postprocessed using a dedicated software. A reference region-of-interest (ROI) in the main portal vein (input function) and distal target ROIs (in the TIPS lumen, in the liver parenchyma and in the right atrium) were placed in corresponding areas on DSA pre- and post-TIPS revision. Time to peak (TTP), peak density (PD), and area under the curve (AUC) were assessed. The ratios of reference ROI to target ROIs (TTParenchyma/TTPinflow; PDparenchyma/PDinflow; AUCparenchyma/AUCinflow; TTPTIPS/TTPinflow; PDPtIPS/PDinflow; AUCTIPS/AUCinflow; TTPatrium/TTPinflow; PDAtriump/Dinflow; and ADatrium/AUCinflow) pre- and post-TIPS revision were calculated. Pressure measurements pre- and post-TIPS revision were performed and correlated to 2D-PA parameters.

**Results:** The portosystemic pressure gradient was significantly reduced following TIPS revision (17.1 ± 6.3 vs. 8.9 ± 4.3 mm Hg; p < 0.0001). PDTIPS/PDinflow (0.22 vs. 0.35; p = 0.0014) and AUCTIPS/AUCinflow (0.24 vs. 0.39; p = 0.0012) increased significantly as well as PDatrium/PDinflow (0.32 vs. 0.78; p = 0.0004) and AUCAtriump/AUCinflow (0.3 vs. 0.79; p < 0.0001), whereas PDparenchyma/PDinflow decreased significantly (0.14 vs. 0.1; p = 0.0084). The changes of the pressure gradient correlated significantly with the increase in PDatrium/PDinflow (r = -0.77, p = 0.0012) and AUCAtriump/AUCinflow (r = -0.76, p = 0.0018).

**Conclusions:** 2D-PA offers an objective approach to quantify perfusion changes during TIPS revision and may therefore be used to monitor peri-interventional TIPS function and to quantify technical success.

### 3:45 PM  
**Abstract No. 287**

**Increase in muscle mass after transjugular intrahepatic portosystemic shunt (TIPS) creation is a prognostic indicator for survival in cirrhosis**

P. Pathak1, Y. Jahangiri1, L. Li1, B. Schlansky2, K. Farsad3; 1Charles T. Dotter Department of Interventional Radiology, Oregon Health and Science University, Portland, OR; 2Department of Internal Medicine, Portland VA Medical Center, Portland, OR

**Purpose:** To assess changes in skeletal muscle volume and density after TIPS creation.

**Materials:** Patients with cirrhosis undergoing TIPS creation at a single institution between 2004 and 2015, and who had available pre- and post-TIPS contrast-enhanced CT scans, were reviewed (n = 80). Subjects who had received liver transplantation prior to TIPS creation or during the observation period (n = 4) were excluded. Cross sectional muscle area and density (psoas, paraspinal, abdominal wall) were measured with free-hand region of interest at the mid L4 vertebral body level before and after TIPS creation. Differences were compared using the paired t-test. Pairwise correlation analysis was performed to evaluate associations between baseline muscle area and clinical characteristics with post-TIPS changes. Predictors of overall survival were assessed using univariate and multivariate Cox proportional hazard models adjusted for age, sex, HCV infection, hepatocellular carcinoma, diabetes, MELD score and baseline muscle measurements. P values < 0.05 were considered significant.

**Results:** Significant increases in psoas, paraspinal, and total muscle areas were observed after TIPS creation (P < 0.001, 0.004,
Impact of PTFE-covered TIPS position relative to the hepatocaval junction on shunt patency

J. Serna1, T. Clark2, M. Dagli3, J. Mondschein4, R. Shlansky-Goldberg5, S. Stavropoulos6, M. Soulen7, S. Trerotola8, G. Nadolski1; 1University of Pennsylvania, Philadelphia, PA; 2Penn Presbyterian Medical Center, Philadelphia, PA; 3N/A, Philadelphia, PA; 4Hospital of the University of Pennsylvania, Moorestown, NJ; 5University of Penn. Med Ctr., Philadelphia, PA; 6University of Pennsylvania, Bryn Mawr, PA; 7University of Pennsylvania, Lafayette Hill, PA; 8University of Pennsylvania Medical Center, Philadelphia, PA

Purpose: Distance from the hepatocaval junction (HCJ) to the hepatic venous (HV) end of transjugular intrahepatic portosystemic shunts (TIPS) created with bare-metal stents (BMS) has been shown to impact patency. Now, most TIPS are created with polytetrafluoroethylene (PTFE)-covered stent-grafts. This study investigates the effect of the distance from the HCJ on patency of PTFE-covered TIPS.

Materials: PTFE-covered TIPS placed between 2002 and 2016 were retrospectively reviewed. Clinical and imaging data were collected from the electronic medical record and radiology imaging archive. Distance from HV end to the HCJ was recorded using the post-TIPS placement venogram performed with a calibrated marker catheter for reference. Primary patency rates were calculated. Differences between groups based on distance from HV end to HCJ were compared using Kaplan-Meier and Cox regression analyses.

Results: Of the 413 PTFE-covered TIPS placed during this time period, 393 had images available to evaluate distance from HV end to the HCJ. 278 TIPS were placed with a single stent-graft while 115 were extended at the HV end with additional stents. TIPS with a HV end flush with the HCJ had 1 and 2-year primary patency rates of 79% and 72% compared to 76% and 70% for TIPS whose HV end did not terminate at the HCJ (p = 0.88). For alternate thresholds of <5, 10, or 15 mm from HV end to HCJ, p-values for Cox regression analyses were 0.87, 0.47, and 0.39 respectively. In TIPS created with a single stent-graft, 1 and 2 year primary patency rates were 80% and 77% compared to 73% and 61% for those using multiple stents (p = 0.043; HR1.57, CI1.02-2.42).

Conclusions: When the HV end of a PTFE-covered TIPS is within 15 mm of the HCJ, primary patency rates of all TIPS are similar. TIPS created with multiple stents are associated with lower primary patency rates than those created with single stents. Thus, when creating a PTFE-covered TIPS, extending the HV end of TIPS is unnecessary if a single stent is within 15 mm of the HCJ.
Changes in kidney function and model of end-stage liver disease score in diabetic patients undergoing the transjugular intrahepatic portosystemic shunt procedure

S. Chiu1, K. Mahmoud2, M. Shoreibah2, S. Moawad2, M. Massoud1, S. Kim1, N. Ertel2, R. Oser2, S. Saddekni2, B. Hamed2, O. Massoud2, A. Abdel Aal2; 1University of Alabama at Birmingham School of Medicine, Birmingham, AL; 2University of Alabama Birmingham (UAB), Birmingham, AL

Purpose: Diabetes is an important comorbidity present in up to 30% of patients with liver cirrhosis. The purpose of our study was to determine the impact of diabetes on the renal function and survival after transjugular intrahepatic portosystemic shunt (TIPS) procedure.

Materials: We reviewed the medical records of 387 patients who had successful TIPS between September 2004 and September 2016. The patients were divided into two groups; group A (diabetics, n = 186) and group B (non-diabetics, n = 201). The glomerular filtration rate (GFR) and model for end-stage liver disease (MELD) score before and within 1 month after TIPS placement were recorded in each group. A threshold GFR and MELD score associated with mortality was estimated in each group.

Results: The study included 261 (62%) males, 373 (88%) whites, and 186 (45%) diabetics, with an average age of 59 (SD = 9.7) for diabetics and 54.7 (SD = 9.6) for non-diabetics. Before TIPS, there was a statistically significant difference between diabetics and non-diabetics in mean GFR (63.3 versus 80.9 respectively, p = 0.0001) and in MELD score (13.3 versus 12.3 respectively, p = 0.0123). In spite of the significant change in MELD score after TIPS in diabetics and non-diabetics (p < 0.0001), there was no significant change in the GFR after TIPS in either diabetics (p = 0.3345) or non-diabetics (p = 0.5065). Lower pre-TIPS GFR was significantly associated with mortality in diabetics [HR = 0.989, CI (0.98-0.99), p = 0.039], while higher pre-TIPS MELD score was associated with mortality in both diabetics [HR = 1.07, CI (1.00-1.14), p = 0.0398] and non-diabetics [HR = 1.08, CI (1.03-1.14), p = 0.001]. The threshold of pre-TIPS GFR and MELD score in discriminating survival in diabetics was 54 (p = 0.0339) and 12 (p = 0.0398). Non-diabetic status was a significant contributor to survival [HR = 0.74, CI (0.55-0.99), p = 0.043].

Conclusions: TIPS does not significantly change the GFR in diabetics. However, pre-TIPS lower GFR and higher MELD score were associated with mortality after TIPS in diabetic patients. The best survival outcome was seen in patients with GFR > 54 and MELD < 12, and the absence of diabetes was a significant contributor to survival in cirrhotic patients undergoing TIPS.

4:12 PM Abstract No. 290

MELD, MELD-Na, serum creatinine, and serum albumin as predictors of mortality after transjugular intrahepatic portosystemic shunt (TIPS) creation with covered stents

M. Joh1, E. Li1, M. Mutonga1, N. Ali1, A. Riaz2, L. Kulik1, R. Lewandowski3, B. Thornburg4; 1Northwestern University, Feinberg School of Medicine, Chicago, IL; 2Northwestern Medicine, Chicago, IL; 3Northwestern University, Chicago, IL; 4Northwestern Memorial Hospital, Chicago, IL

Purpose: To assess the prognostic value of MELD, MELD-Na, and laboratory data for the prediction of mortality after transjugular intrahepatic portosystemic shunt (TIPS) creation using polytetrafluoroethylene (PTFE)-covered stents.

Materials: With IRB approval, 351 patients who underwent TIPS between 2005 and 2015 using PTFE-covered stents were reviewed. Clinical lab values, transplantation status, and survival were recorded and analyzed. One- and 3-month mortality following TIPS was assessed using Area Under Receiver Operating Characteristic (AUROC) curves. Transplant free survival (TFS) was analyzed using Cox proportional-hazards regression models. Statistical analysis was performed using commercially available software (MedCalc; MedCalcSoftware, Mariakerke, Belgium) at significance level of 5%.

Results: TIPS was successful in all 351 patients. All received VIATORR covered stents (Gore & Associates, Flagstaff, Arizona). Median age was 58 y (range, 19-83). The most common causes of cirrhosis were ETOH (n = 92, 26%), viral hepatitis (n = 62, 18%) and NASH (n = 59, 17%). The most common indications for TIPS were refractory ascites (n = 151, 43%) and variceal bleeding (n = 98, 28%). Median baseline MELD score was 13 (range, 6-45) and MELD-Na score was 17 (range, 6-45). Both MELD and MELD-Na accurately predicted early mortality a 1 mo following TIPS, with AUROC of 0.782 and 0.753 (p < 0.0001 and p < 0.0001 respectively). Similarly, at 3 mo following TIPS, MELD and MELD-Na AUROC were 0.629 and 0.661 (p = 0.026 and p = 0.005 respectively). There was no difference in the prognostic ability of MELD and MELD-Na for mortality at 1 and 3 mo (p = 0.13 and p = 0.28 respectively). Hazard ratios (HR) for MELD and MELD-Na in transplant-free survival (TFS) were calculated to be 1.07 [1.05, 1.10] and 1.07 [1.03, 1.11] (p < 0.0001 and p = 0.0002 respectively). Serum creatinine and albumin had HR of 1.21 [1.06, 1.4] and 0.54 [0.39, 0.74] (p = 0.0055 and p = 0.0002 respectively) in predicting TFS. HR for bilirubin/INR were not significant.

Conclusions: MELD and MELD-Na scores predicted early mortality after TIPS creation with covered stents with similar accuracy. In addition to MELD and MELD-Na scores, serum albumin and creatinine strongly predicted TFS.
Scientific Session 30

Education and Training

Tuesday, March 20, 2018
3:00 PM–4:30 PM
Room: 409B

3:00 PM
Abstract No. 292

Meritocracy or the old boys club? #TimeToTalk
N. Kothary1, C. Obi2, G. Hwang3, M. Perez4, M. Fassiotto5; 1Stanford, CA; 2Stanford Hospital and Clinics, Sunnyvale, CA; 3Stanford University, Hillsborough, CA; 4Stanford University School of Medicine, Stanford, CA; 5Stanford University School of Medicine, Palo Alto, CA

Purpose: In national scientific meetings, an invitation to coordinate and lead a plenary session, categorical course or symposium epitomizes expertise and thought leadership. For women Interventional radiologists (WIR), the quintessential “glass-ceiling”—the lack of advancement into leadership positions—still exists. Herein we report gender trends for invited faculty coordinators at the past three annual scientific meetings for the Society of Interventional Radiology (SIR).

Materials: Faculty rosters for the SIR Annual Meetings from 2015-17, archived by the SIR administration, were reviewed. Faculty leads (coordinators) for plenary sessions, categorical courses, symposia, and “meet-the-expert” sessions were identified. Keynote events and award ceremonies were excluded from the analyses.

Results: For each year from 2015-17, there were 126, 192 and 153 faculty invited to coordinate 71, 105, and 93 sessions, respectively. In 2017, 20 WIR were invited to coordinate 19 sessions (13%), an increase from 2015 and 2016 that saw 9 (7%, 8 sessions) and 8 (4%, 7 sessions) WIRs, respectively. Collectively, over the 3 years, nine WIR coordinated 61% of all sessions led by WIR (22 of 36 sessions). There were 7 “meet-the-expert” sessions in 2015 that increased to 37 sessions in 2016 and 2017 with 12, 65 and 39 invited coordinators, respectively. Of these experts, WIR comprised 0%, 4.6% (n = 3) and 7.7% (n = 3), respectively. Finally, subject matter expertise for the 36 WIR-led sessions was concentrated to economics (9/36, 25%), education (5/36, 14%), Women’s health (4/36, 11%), and pediatric IR (3, 8%), while oncology, arterial disease, deep venous thrombosis or portal hypertension sessions saw minimal or no WIR representation in leadership or coordinator positions.

Conclusions: SIR is committed to a more diverse and inclusive workforce, and the new IR residency will mold the next generation of IRs. To achieve gender equity though and foster diversity, it is important to have more women in leadership roles.

3:09 PM
Abstract No. 293

Guide on ultrasound: the efficacy of a short, reproducible, interactive course aimed at improving core ultrasound procedural competencies in fourth year medical students
G. Gadodia1, V. Kumar2, M. Conrad3, D. Naeger4, E. Webb5; 1Cleveland Clinic, Cleveland, OH; 2UCSF, San Francisco, CA; 3University of California, San Francisco, San Francisco, CA; 4University of California, San Francisco, United States; 5University of California, San Francisco, San Francisco, CA

Purpose: Residents in many specialties perform ultrasound-guided procedures regularly; however, few medical school curricula offer formal education on the topic. The purpose of this study is to evaluate the efficacy of a reproducible, two-day, interactive course aimed at improving core ultrasound procedural competences in fourth year medical students.

Materials: All medical students enrolled in a fourth year radiology elective from 2015 to 2017 at an academic medical center attended a two-day interactive ultrasound course led by interventional radiology (IR) faculty. Students completed an anonymous web-based survey before and after the session. Survey topics included knowledge of ultrasound anatomy, transducer selection, procedure identification, and procedural safety (including needle tip versus shaft recognition). Average scores were calculated for each pretest and posttest category and paired sample t-tests were used to evaluate the improvement in each category, with a significance value of 0.01 after Bonferroni correction.

Results: 138 students completed the course and both the pre- and postintervention tests. Paired t-test data showed significant improvement in scores on questions regarding ultrasound anatomy (mean scores: +18%, 95% CI: ± 5%, p < 0.001), transducer selection (+33%, ± 6%, p<0.001), procedure identification (+23%, ± 5%, p < 0.001), and questions regarding confirmatory safety measures, e.g., needle tip versus shaft recognition (+34%, ± 5%, p < 0.001).

Conclusions: Ultrasound-guided procedures, including paracenteses, thoracenteses, and central line placements, are performed by residents in a variety of specialties, despite the lack of formal education in medical school curricula. Medical students demonstrated significant improvement in key ultrasound procedural competencies following a short, reproducible, interactive course led by IR faculty. Implementation of a similar hands-on session in other curricula may improve procedural competency of future residents and, ultimately, patient safety.

3:18 PM
Abstract No. 294

Determining endovascular proficiency among interventional radiology practitioners using a homemade physical simulator and simulation-based metrics
K. Karuppasamy1, J. Edwards1, J. Bullen1; 1Cleveland Clinic, Cleveland, OH
**Effect of gender on trainee evaluations of faculty**

M. Koran1, M. Fassiotto1, G. Hwang1, Y. Maldonado1, N. Kothary1; 1Stanford University Medical Center, Stanford, CA

**Purpose:** Feedback provided by trainees is an important criterion for promotion in academia. Understanding the influence of gender bias, especially for physicians who contradict stereotypes, is crucial. Herein we report trainee evaluations for faculty, with particular attention to surgical fields, including catheter lab-based specialties.

**Materials:** Between July 2010 and 2015, trainees at a tertiary hospital evaluated 1329 faculty with clinical duties (454 surgical faculty, 875 non-surgical faculty). Anonymized evaluations were processed through a graduate education management system that arrived at an objective score (1-10) by averaging individual trainee scores for the faculty for each year. The effects on score of variables including gender, rank, track and ethnicity were tested.

**Results:** A total of 4612 evaluations were analyzed. The overall median score was 9.26 (range, 3.01-10). Male gender, nonsurgical specialty, professoriate track, and professorial rank were all favored (p = 0.003, p<0.001, p<0.001, p<0.001, respectively). After controlling for rank and track, the overall effect of gender disappeared, indicating that the low representation of women at professorial rank and professoriate track drove lower median scores. However, the effect of gender remained for surgical specialties, despite controlling for rank and track, with female surgeons receiving significantly lower median scores than male surgeons and physicians in medical specialties (p = 0.04).

**Conclusions:** Overall female physicians received lower median scores, likely effected by greater populace at lower ranks and in non-professorial tracks. Female physicians in male-dominated surgical specialties, by contradicting perceived sex-role expectations, may have faced negative stereotyping, fairing far less favorably compared to their female counterparts in medical specialties, and to all male physicians irrespective of their specialty.
Conclusions: IR exposure in the preclinical and clinical years with implementation of a formal curriculum and repetitive exposure has increased both knowledge and interest in the field. Increased student exposure will aid in recruitment to our field as well as allow students specializing in other fields to understand the diverse utility of IR in their future practices.

3:45 PM Abstract No. 297

Custom 3D-printed ultrasound-compatible vascular access models: training medical students for vascular access
A. Sheu¹, G. Laidlaw², J. Fell¹, B. Triana¹, C. Goettl¹, R. Shah¹, ¹Stanford Medicine, Stanford, CA; ²University of Washington, Seattle, WA

Purpose: Commercially available US-guided vascular access models (CM) simulate anatomic and US-visible landmarks; however, they are expensive and do not simulate variant anatomy. The purpose of this study was to compare training efficacy between CM and a novel 3D-printed US-compatible vascular access model (3DPVAM) using a simulation experience (SE) directed at medical students. We hypothesized that student comfort with US-guided femoral artery (FA) access increases after SE, and that 3DPVAM and CM SE efficacy are comparable.

Materials: A 3DPVAM of normal FA anatomy was developed from an anonymized CT exam. After IRB approval, students were randomized to 3DPVAM or FemoraLineMan CM (Simulab) SE. Students completed a pre-SE questionnaire ranking comfort with FA access on a Likert scale. A standardized SE was administered by IR faculty. Students completed a post-SE questionnaire ranking comfort with FA access on a Likert scale. Student questionnaire results were compared between 3DPVAM and CM groups using Chi-square, Wilcoxon signed-rank, and non-inferiority analyses.

Results: 15 and 17 students were randomized to 3DPVAM and CM training, respectively. 93.3% of 3DPVAM trainees and 100% of CM trainees had attempted FA access. 73.3% of 3DPVAM trainees and 76.5% of CM trainees did not feel confident performing FA access. After training and SE, most 3DPVAM and CM trainees agreed that the model was easy to use (93.3% and 94.1%, respectively) and helpful for practice (93.3% and 94.1%). In both groups, training increased subjective student confidence by 2 Likert points (3DPVAM p = 0.001; CM p = <0.0001). The subjective confidence increase in 3DPVAM trainees was non-inferior to that in CM trainees (noninferiority margin 1 Likert point, p=0.0001).

Conclusions: Generation of an inexpensive custom 3DPVAM and SE is feasible and produces comparable subjective training outcomes to CM. We aim to extend our SE to resident and fellow trainees and to assess objective improvements in the future. We also aim to develop complex 3DPVAMs of variant anatomy and other body regions with the goal of creating customizable models to improve vascular access outcomes and patient safety across multiple disciplines.

3:54 PM Abstract No. 298

Simulation-based ultrasound-guided breast biopsy training improves operator knowledge, accuracy, and confidence
A. Trace¹, J. Plemmons², G. Wade², C. Elzie²; ¹Eastern Virginia Medical School, Virginia Beach, VA; ²Eastern Virginia Medical School, Norfolk, VA

Purpose: Ultrasound (US)-guided breast biopsy is one of the most common techniques employed to obtained tissue for histologic analysis of breast pathology. Experience performing this procedure is almost entirely on patients, an approach fraught with anxiety and potential error. The aim of this study was to assess the efficacy of a breast-phantom in conjunction with a multimedia educational presentation in improving operator knowledge, procedural accuracy, and subjective comfort performing US-guided breast biopsy.

Materials: Sixteen radiology resident physicians completed a written exam of multiple-choice questions (MCQ) covering the US-appearance of breast anatomy, commonly targeted pathologies, and clinical management of complications. Then residents completed a self-paced, interactive online module describing: mammographic, sonographic, and procedural concepts related to breast biopsy and pathology. Residents were allowed 30 minutes to practice on the breast phantom before completing a formal assessment of US-guided biopsy accuracy graded dichotomously by obtaining a sample of the intended pathology within the phantom. A posttest consisting of pair-matched MCQs was then administered.

Results: The average score on the written pretest was 72.7% and the average post-test score 95.3%, a statistically significant improvement (p<0.001). Accuracy obtaining intended sample correlated with post-graduate year and experience performing US-guided biopsy procedures. There was a statistically significant improvement in residents’ qualitative: comfort explaining the procedure (p<0.01), comfort performing the procedure (p<0.01), and handling complications (p<0.05).

Conclusions: The phantom allowed residents an unrestricted opportunity to practice and refine their technique. The brief educational multimedia presentation and independent practice with the phantom resulted in both objective and subjective improvement in residents’ knowledge, procedural accuracy, and subjective comfort performing US-guided breast biopsy.

4:03 PM Abstract No. 299

Factors influencing selection of an interventional radiology training program
A. Gould¹, O. Akinwande¹, G. Foltz¹, J. Gould¹, C. Molloy², C. Sarah¹, M. Darcy¹, R. Ramaswamy¹; ¹Mallinckrodt Institute of Radiology, St. Louis, MO; ²Kaiser Permanente, Los Angeles, CA

Purpose: Interventional radiology (IR) was awarded primary specialty status by the American Board of Medical Specialties in 2012. The purpose of this study was to investigate the factors that were most important for trainees in selecting an IR training program.
Materials: A thirty-four question IRB-approved survey was administered to the active membership of the Society of Interventional Radiology Residents, Fellows, and Students Section (SIR-RFS) and Association of Program Directors in Radiology (APDR). The survey obtained demographic data and investigated the importance of several factors pertinent to IR training program selection. A 5-point Likert scale was used to grade 22 factors from “not at all important” (1) to “very important.” (5).

Results: A total of 181 responses were completed with 142 males (79.8%) and 36 females (20.2%) with an average age of 29.2 years. Respondent composition was 72 (40.45%) medical students, 96 (53.93%) residents, and 10 (5.62%) fellows. 52 respondents (28.9%) are planning on applying to residency and planning on entering the IR residency match for 2018. The top 5 rated out of 22 possible factors were diagnostic radiology class size (2.67 ± 0.47), procedural volume (4.63 ± 0.54), perceived happiness of the trainees at the institution (4.52 ± 0.70), job placement/accomplishments of prior fellows (4.44 ± 0.75), and interpersonal interactions with faculty/fellows/residents during interview (4.39 ± 0.79). The lowest 5 rated factors were variety of IR cases (4.81 ± 0.47), procedural volume (4.63 ± 0.54), perceived happiness of the trainees at the institution (4.52 ± 0.70), job placement/accomplishments of prior fellows (4.44 ± 0.75), and interpersonal interactions with faculty/fellows/residents during interview (4.39 ± 0.79). The lowest 5 rated factors were diagnostic radiology class size (2.67 ± 1.15), moonlighting opportunities (2.93 ± 1.18), potential for research opportunities (3.19 ± 1.15), salary/benefits/compensation (3.22 ± 1.03), and ICU rotation experience (3.22 ± 1.28).

Conclusions: Potential future trainees most value diversified procedural exposure, employment opportunities after training, and interpersonal interactions in choosing an IR program. This information is useful to newly established IR residencies seeking to best structure and market their program.

4:12 PM Abstract No. 300

Train where you want to work? The association of residency and fellowship with academic attending practice location
S. Golden1, E. Golden1, P. Yi2, O. Ozkan1; 1University of Wisconsin, Madison, WI; 2Johns Hopkins Hospital, Baltimore, MD

Purpose: Conventional wisdom is to complete fellowship in one’s desired geographic area of practice after training. The purpose of this study was to assess whether academic IRs are more likely to practice near their residency or fellowship.

Materials: Fellowship and residency locations of IR faculty at 30 academic institutions (n = 275) were identified using departmental websites. Attendings who did not complete residency and IR fellowship in the U.S. were excluded. The institutions were selected from the Doximity Diagnostic Radiology Residency Navigator, sorted by reputation. Distances between residency and fellowship city and attending practice location were calculated using Google Maps Distance Matrix API. Institutions were grouped by region (e.g. Midwest) and population (within top 12 U.S. metropolitan areas, or outside top 12 U.S. metropolitan areas). The proportions of attendings practicing at the same institution, city, or within 50, 100, or 250 miles of their residency or fellowship were compared using Fisher’s exact test. Subgroup analysis was performed by geographic region and city population.

Results: More than half (52%) of attendings practiced in the same city as their fellowship, significantly greater than the proportion (38%) who practiced in the same city as their residency (p = 0.001). A significant difference was also observed when assessing the proportion who practiced at the same institution, within 50 miles, and within 100 miles (all p < 0.05) of their fellowship or residency location. Attendings who practiced in a top 12 metropolitan area were significantly more likely to have completed fellowship in the same city (45%) than those who practiced outside of these areas (30%, p = 0.013). There was a significant difference between geographic regions in the proportion of attendings who practiced within 50 miles of their fellowship (p = 0.001). The proportion was highest in the Northeast (66%) and lowest in the Rocky Mountain (14%) region.

Conclusions: Fellowship is more closely associated with the practice location of academic interventional radiologists than residency. Those who practice in large cities and the Northeast are more likely to practice close to where they trained for fellowship.

4:21 PM Abstract No. 301

The dramatic shift in professional values of interventional radiology fellows
E. Keller1, S. Trerotola2, M. Johnson3, K. Valji4, K. Sato5, R. Vogelzang6; 1Northwestern University, Feinberg School of Medicine, Chicago, IL; 2University of Pennsylvania Medical Center, Philadelphia, PA; 3Indiana University, Carmel, IN; 4University of Washington, Seattle, WA; 5Northwestern University, Chicago, IL; 6Northwestern Memorial Hospital, Chicago, IL

Purpose: This project sought to characterize the shifting professional values and concerns of interventional radiology (IR) fellows to allow educators to better shape the future role of the specialty.

Materials: We compared the results of ethnographic interviews with fifteen 2015-2016 and twenty-eight 2017-2018 IR fellows at the beginning of their fellowships at the same 4 institutions. Fellows were asked about their journey to the specialty, what makes a “good” IR, their interactions with patients and providers, and the future of the specialty with probing for further detail. Interviews were transcribed verbatim and systematically coded for themes and trends by a single experienced qualitative researcher. Two-tailed t-tests were used to quantitatively compare interview theme frequencies between groups.

Results: Participating fellows (n = 43) were 32 ± 3 years old with 6 women and similar demographics between past and current fellows (p > 0.05). Both groups described similar pathways to IR with early interest in radiology or surgical fields. Fellows consistently valued working with their hands, thinking on their feet, and innovation. However, current fellows described ideal traits in much more clinically focused terms (p < 0.01), more consistently emphasizing the importance of understanding patients’ values and goals of care, rousing on patients, and follow-up clinics. Tension between diagnostic and interventional radiology was the primary inter-disciplinary concern of current fellows rather than competition emphasized by past fellows.

Conclusions: IR fellows have become more clinically focused with better defined perceptions of IR’s clinical role, and the magnitude of this shift was surprisingly large. Tension between IR and DR rather than other specialties may be an important concern to address with the implementation of IR residency programs.
Preoperative Gelfoam uterine artery embolization (UAE) prior to laparoscopic myomectomy for large (>5 cm) and/or multiple fibroids

S. Golden1, C. King1, P. Laeseke1, M. Woods2; 1University of Wisconsin, Madison, WI; 2University of Wisconsin, Verona, WI

Purpose: Myomectomy is currently the recommended treatment option for women with fibroids who wish to preserve fertility. Laparoscopic myomectomy is associated with decreased morbidity and increased patient satisfaction; however, it does carry the risk of significant hemorrhage requiring transfusion or conversion to laparotomy. The aim of this study is to examine whether preoperative UAE with Gelfoam reduces bleeding during laparoscopic myomectomy in patients with large and/or multiple fibroids.

Materials: All patients (n = 17) who underwent combination preoperative UAE with Gelfoam and laparoscopic myomectomy at a single tertiary care center between July 2016 and September 2017 were identified. All laparoscopic myomectomies were performed by a single surgeon on the same day as UAE (n = 1) or the day after UAE (n = 16). A retrospective chart review was performed to assess fibroid size and number, operative blood loss, operative time, length of hospital stay, and procedural complications. Results were compared to the published literature.

Results: Mean diameter of the dominant fibroid was 9.0 cm (range, 4.0-13.0). Mean clinical uterine size was 16 weeks (8-25 weeks). Mean pathologic specimen weight was 496 g (51-1272 g). Approximately one half (8/17) of patients had greater than two fibroids. The median operative blood loss was 100 mL (20-3000 mL), and mean operative time was 216 minutes (70-343 min). One patient required transfusion and conversion to abdominal myomectomy. There were no other complications. Median length of stay was two nights (1-4 nights).

Conclusions: Median operative blood loss in our case series was less than results published in the literature using a laparoscopic approach without preoperative UAE (range, 129-248 mL), despite a larger average fibroid size in our cohort. To our knowledge, this represents the largest case series of preoperative UAE before laparoscopic myomectomy. Our experience suggests that preoperative UAE is an effective adjunctive treatment that reduces operative blood loss during surgical removal of large or multiple fibroids, enabling a laparoscopic, fertility sparing approach.

How peripheral embolic coil design differences affect embolic efficacy

R. Dunlap1, K. Reichel2, K. Hong3; 1Johns Hopkins Hospital, Baltimore, MD; 2Johns Hopkins Hospital, Baltimore, MD; 3Johns Hopkins Hospital, Woodstock, MD

Purpose: Embolic coils have been used for peripheral embolization since the 1970s with many commercially available designs. However, coil design differences relating to embolization efficacy is not well understood. We aim to test some of the variables used in
commercially available coils, including coil size, fiber, fiber material, and expanding gel and compare how these differences affect embolic efficacy using a swine model.

**Materials:** Paired arteries were selected and embolized utilizing 2 protocols. Standard clinical embolization practice and flow scoring (TIMI grading) was employed across the study. The first protocol contained two groups; Dacron fiber coil (Interlock 18 Bos. Sci.) vs. nylon/PGLA coil (Concerto Covidien) and Dacron fiber coil (Interlock 18) vs. hydrogel coil (Azur Terumo). Selected arteries fit predetermined size and configuration criteria. The second protocol contained a single group comparing fibered 0.018 coils vs. nonfibered (fibered & nonfibered interlock 18) and compared the effect on coil diameter (Interlock 18 vs. Interlock 35); similar single arteries were selected with three treatment areas. Paired arteries (3) were occluded in each animal and 6 sets were occluded for each group. Occlusion efficiency was assessed by the number of coils used, unit length of coils and the amount of time required for complete embolization.

**Results:** Average occlusion time was quickest for the Interlock 18 and 35, both at mean time of 10.7 min. The Interlock 18 used less coils (mean # of coils 2.9 vs 3.5) and unit length of coil (50.3 and 65.0 cm). The longest mean occlusion time was for the Azur at 19.4 mins and utilizing an average of 4.8 coils and 95.2 cm unit length. Most efficacious was Interlock 18, which was 47% better in embolization time and 48% better in mean coil length for complete embolization, than the least, the Azur. On average, coils with fiber had shorter occlusion time than those without (10.7 vs. 15.3 mins) and utilized less coils (2.9 vs. 4.2).

**Conclusions:** Fibered coils, specifically Dacron fibers, have an improved embolization efficacy over those without fiber (and hydrogel) as measured by embolization time, number of coils, and unit length of coil used in an animal model.

**Abstract No. 305**

**Vascular selectivity of radiopaque beads during transarterial embolization**

M. Doshi¹, P. Mohan², A. Hanson², A. Amin³, N. Salas¹, R. Lencioni¹, G. Narayanan⁴; ¹University of Miami, Miami, FL; ²University of Miami Miller School of Medicine, Miami, FL; ³University of Miami Miller School of Medicine, Miami, FL; ⁴University of Miami Miller School of Medicine, Miramar, FL

**Purpose:** To determine if LUMI bead size, injection rate, or concentration affects the ability to embolize blood vessels further into the periphery of the organ.

**Materials:** A total of 9 Yorkshire pigs underwent fluoroscopy-guided injection of LUMI radiopaque beads using 2 different LUMI bead sizes (R0 = 40-90 and R1 = 70-150 microns). Each animal was injected with 1 of 3 bead/Visipaque 320 contrast concentrations (1:4, 1:9, and 1:14) and at 1 of 3 injection rates (0.5 mL/min, 1.0 mL/min, and 1.5 mL/min). Isovue contrast was used to position the catheter and allow for direct injection of the embolization beads into the arterial branch of the liver and kidneys. The R1 and R0 beads were used to embolize the left kidney and left hepatic lobe and the right kidney and right hepatic lobe, respectively. The animals were subsequently euthanized. The distance of the beads from the hilum and the capsule was then evaluated with imaging and pathological correlation.

**Results:** Technical success rate was 100% (36/36). Embolization was achieved regardless of the injection rate and concentration. The complication rate after the embolization process was 0% (0/36). In the liver, the beads traveled more distally from the hilum for lower concentrations (P = .008), but this was not statistically significant for the kidney (P = .279). When comparing the distance traveled by the beads from the hilum with changes in the injection rate, the difference was not statistically significant for the liver or kidney (P = .985 and P = .907, respectively). When comparing the distance traveled by the beads from the hilum with changes in the bead size, the difference was not statistically significant for the liver or kidney (P = .779 and P = .244, respectively). However, in the kidney, when measuring the distance from the beads to the capsule, lower bead sizes demonstrated greater peripheral distribution (P = .007).

**Conclusions:** Lower concentrations and smaller bead sizes appear to demonstrate a more peripheral distribution, although this may be organ dependent. However, bead distribution does not appear to be affected by injection rate.

**Abstract No. 306**

**Optimal delivery rate and concentration of radiopaque beads for transarterial embolization**

M. Doshi¹, P. Mohan², A. Amin³, A. Hanson³, N. Salas¹, R. Lencioni¹, G. Narayanan⁴; ¹University of Miami, Miami, FL; ²University of Miami Miller School of Medicine, Miami, FL; ³University of Miami Miller School of Medicine, Miami, FL; ⁴University of Miami Miller School of Medicine, Miramar, FL

**Purpose:** To determine how changes in the standard injection rate (1.0 mL/min), in the standard concentration (1:9), or the size of the LUMI beads affect the embolization volume.

**Materials:** A total of 9 Yorkshire pigs underwent fluoroscopy-guided injection of LUMI radiopaque beads using 2 different LUMI bead sizes (R0 = 40-90 and R1 = 70-150 microns). Each animal was injected with 1 of 3 bead/Visipaque 320 contrast concentrations (1:4, 1:9, and 1:14) and at 1 of 3 injection rates (0.5 mL/min, 1.0 mL/min, and 1.5 mL/min). Isovue contrast was used to position the catheter and allow for direct injection of the embolization beads into the arterial branch of the liver and kidneys. The larger LUMI beads (70-150 microns) were used to embolize the left kidneys and left hepatic lobes and the smaller LUMI beads (40-90 microns) were used to embolize the right kidneys and right hepatic lobes. The animals were subsequently euthanized. The distance of the beads from the hilum was then evaluated with imaging and pathological correlation.

**Results:** Technical success rate was 100% (36/36). Embolization was achieved regardless of the injection rate and concentration. The complication rate after the embolization process was 0% (0/36). When measuring the effect of concentration on embolization volume, higher concentrations correlated with decreased embolization volumes in both the liver and kidney (P = .018 and P = .001, respectively). Smaller bead sizes also correlated with decreased embolization volume in both the liver and kidney (P = .014 and P = .048, respectively). However, different injection rates did not result in a statistically significant difference in embolization...
Conclusions: Increased concentration and smaller bead sizes appear to decrease embolization volume. However, changes in the injection rate do not appear to affect the embolization volume.

3:45 PM Abstract No. 307

Comparison of efficacy and cost of embolic materials for translumbar type 2 endoleak repairs performed with Trufill vs Histoacryl n-butyl cyanoacrylate
D. Anand1, V. Ramakrishnan2, H. Yu1, A. Isaacson1, R. Dixon2, 1University of North Carolina, Chapel Hill, NC; 2Virginia Tech Carilion School of Medicine, Roanoke, VA; 3UNC Dept. of Radiology, Chapel Hill, NC

Purpose: To retrospectively compare the efficacy of two type 2 endoleak repairs and costs of embolic materials when one of two different formulations of n-butyl cyanoacrylate (nBCA), Trufill and Histoacryl, were used.

Materials: Between January 2015 and February 2017, 47 abdominal aortic aneurysm translumbar endoleaks were performed at a single institution. Procedures were excluded from analysis if the endoleak was not type 2, if there was more than one endoleak present, if there was associated aneurysm rupture, if there was concurrent infection at time of repair, if translumbar access was not used, if nBCA was not used or if there was no follow-up imaging available. Incidence of aneurysm sac enlargement and cost of embolic materials were recorded and compared. Unpaired t-tests were used to determine statistical significance set at p = 0.05.

Results: Six endoleak repairs with Trufill and six with Histoacryl were included in the analysis. In conjunction with Trufill, coils were used in 6/6 (100%) repairs. In conjunction with Histoacryl, coils were used in 5/6 (83%) repairs. Mean duration prior to follow-up scan was 169.5 ± 70.4 days and 155.2 ± 67.5 days for Trufill and Histoacryl, respectively (p = 0.73). Aneurysm sac enlargement was seen after 1/6 (17%) Trufill repairs and 0/6 (0%) Histoacryl repairs (p = 0.34). Mean cost of embolic materials was $4975 ± 435 and $1595 ± 310 for Trufill and Histoacryl repairs, respectively (p<0.0001). No major complications associated with embolization were noted in either group.

Conclusions: Trufill and Histoacryl can both be used effectively for translumbar type 2 endoleak repair. However, total embolic material costs are significantly less when Histoacryl is used.

4:03 PM Abstract No. 309

Transarterial embolization of renal cell carcinoma as an adjunctive therapy prior to cryoablation: a propensity score matching analysis
A. Gunn1, B. Mullenbach2, M. Poundstone3, S. Klimkowski2, J. Gordetsky3, S. Rais-Bahrami1; 1University of Alabama at Birmingham, Birmingham, AL; 2N/A, Charlotte, NC; 3UAB Department of Radiology, Birmingham, AL

Purpose: To assess the safety and efficacy of transarterial embolization (TAE) prior to percutaneous cryoablation (PCA) in the management of RCC compared to PCA alone using a propensity score matching analysis to minimize confounding factors.

Materials: A retrospective review of all PCAs performed for RCC between 1/1/2008 and 12/31/2016 identified nine patients who underwent TAE of their RCC prior to PCA. These patients were matched in a 1:2 ratio with patients who underwent PCA only using age, gender, and tumor size to create the propensity score model for matching. Other demographic, clinical, and outcomes data were also collected.

Results: The TAE+PCA group included 5 males and 4 females with a mean age of 67.9 years and mean tumor diameter of
PCA only groups had a 2.1% and 9.3% drop in hematocrit, oablation (p = 0.78). The TAE+PCA and PCA only groups had a 2.8% decrease and 1.0% decrease in hematocrit, respectively (p = 0.48). The TAE+PCA and PCA only groups had a 2.8% decrease and 1.0% decrease in eGFR, respectively (p = 0.69). The TAE+PCA and PCA only groups had a 2.1% and 9.3% drop in hematocrit, respectively (p = 0.15). Four patients in the TAE+PCA group and seven patients in the PCA only group required repeat cryoablation (p = 0.78).

Conclusions: TAE of RCC prior to PCA is safe, technically feasible, and does not adversely affect patient outcomes. Data shows a trend toward less blood loss with this approach; although, this number did not reach statistical significance. Larger prospective studies are needed to assess for potential clinical benefits of this approach.

4:12 PM Abstract No. 310

Transarterial embolization of renal angiomyolipomas: 18-year experience
A. Parvinian1, C. Reisenauer2, E. Bendel1, M. Haddad1, J. Andrews2, C. Fleming2; 1Mayo Clinic, Rochester, MN; 2N/A, Rochester, MN

Purpose: To determine the safety and efficacy of transarterial embolization (TAE) of renal angiomyolipomas (AMLs) and to identify factors associated with need for repeat therapy.

Materials: An IRB-approved retrospective review was undertaken of all patients who underwent TAE of renal angiomyolipomas between January 2000 and July 2017. Patient demographics, lesion characteristics, procedural factors, and clinical outcomes were identified through a review of the electronic medical record and relevant imaging. Complications were graded according to the CTCAE criteria.

Results: Fifty-four patients (12M/42F; mean age 53 years) underwent 78 treatments for 66 renal AMLs. Presenting symptoms included retroperitoneal hemorrhage (n = 9, 13.6%), isolated abdominal pain (n = 7, 10.6%), and hematuria (n = 6, 9.1%); the remainder (n = 44, 66%) were detected incidentally or during screening in patients with tuberous sclerosis (TS). TAE was performed using either absolute ethanol (n = 36), particles (n = 37), or both (n = 5); coils were used in 36 cases. Mean lesion size was 8.0 ± 4.7 cm. There was no significant difference in size between non-hemorrhagic and hemorrhagic lesions (8.0 ± 4.8 cm vs. 7.9 ± 4.3 cm, p = 0.46); however, lesions were significantly larger in patients with TS (10.5 ± 6.4 cm vs. 6.6 ± 3.1 cm, p = 0.01). Eleven lesions required repeat embolization; these were associated with subtotal initial embolization (p = .01). There was no significant association between need for repeat TAE and patient age (p = .51), lesion size (p = .15), embolic agent (p = .21), or presence of TS (p = .19). CTCAE Grade 3 adverse events occurred in 5/78 cases (6.4%), including post embolization syndrome requiring hospitalization for pain control (n = 4) and renal infarction resulting in ureteral obstruction (n = 1). There was no significant difference in complication rate between lesions treated with ethanol or particles (p = .07).

Conclusions: In this cohort, TAE of renal AMLs proved safe and effective. The need for repeat therapy was associated with subtotal initial embolization. Further investigation is needed to delineate the relative efficacy of different embolic agents.

4:21 PM Abstract No. 311

Preoperative uterine artery embolization may reduce blood loss during hysterectomy for select uterine leiomyomata
A. Solomon1, P. Kaushal2, J. Spies2, T. Caridi2; 1The Johns Hopkins Hospital, Baltimore, MD; 2MedStar Georgetown University Hospital, Washington, DC

Purpose: To determine the effect of preoperative uterine artery embolization (UAE) on blood loss during hysterectomy.

Materials: A retrospective query of internal databases selected patients who underwent UAE prior to hysterectomy from 2012-2016. Estimated blood loss (EBL) during hysterectomy, as documented by the gynecological surgeon, was compared between patients who received preoperative UAE and a control group of similarly sized uteri from a previously published study of women undergoing hysterectomy alone. An alternative method for measuring blood loss, as calculated using the Gross Equation, was also compared to EBL for study subjects as a secondary outcome. Data was stratified based on uterine weight. Unpaired Student’s t-test calculated the statistically significant relationships between blood loss in patients who received a preoperative UAE and those who underwent hysterectomy alone.

Results: 19 patients underwent UAE prior to hysterectomy. There was no significant difference in EBL between the control and the preoperative UAE cohort (427.7 ± 305.0 mL vs. 421.3 ± 400.3 mL; p = 0.929). When stratifying according to uterine weight, hysterectomy of intermediate and small uteri trended toward decreased blood loss when preceded by UAE with EBL of 464.3 ± 285.2 mL vs. 337.5 ± 47.9 mL (p = 0.381) and 387.6 ± 281.4 mL vs. 225.0 mL (p = 0.137), respectively. There was significantly more blood loss on overall and sub-group analysis when blood loss was estimated using the Gross Equation rather than surgical documentation.

Conclusions: Although logical and employed in clinical practice, there is little evidence to date supporting the use of prehysterectomy UAE to decrease blood loss during surgery. While this study is limited by sample size and does not show a significant decrease in EBL with preoperative UAE, it does suggest a benefit for patients with small and intermediate size uteri. Larger uteri may have a highly collateralized blood supply, decreasing the efficacy of embolization on intraoperative hemostasis. Further investigation with higher power and more robust measurements of blood loss should be conducted to more clearly elucidate the benefits of UAE prior to hysterectomy.
Feasibility of transarterial delivery of biodegradable nanoparticles for in vivo imaging and combinatorial phototherapy of solid organ tumors
K. Farsad1, M. Horikawa2, Y. Tomozawa2, M. Endo2, K. Hashimoto3, Y. Jahangiri2, O. Taratula4; 1Oregon Health and Science University, Portland, OR; 2Dotter Interventional Institute, Portland, OR; 3Dotter interventional institute, Portland, OR; 4Oregon State University, Corvallis, OR

Purpose: To assess the feasibility of biodegradable nanoparticles to accumulate selectively within hepatic tumors in sufficient concentrations after transarterial delivery for in vivo localization and combinatorial phototherapy under near-infrared light (NIR).

Materials: A VX2 hepatic tumor model was used in New Zealand White rabbits. Transarterial delivery of novel silicon naphthalocyanine loaded biodegradable nanoparticles was performed using a microcatheter via the proper hepatic artery. Prior to nanoparticle delivery, a fluorophore detecting reactive oxygen species (ROS) formation (H2DCFDA) was injected into the hepatic artery. Thirty minutes after ROS agent delivery, hepatic tumors were exposed via laparotomy. Nanoparticles were infused directly into the hepatic artery and observed under 785nm wavelength NIR. A handheld NIR laser at 0.9 W/cm² was then applied 5-10 mm over tumor or the background liver control and a fiberoptic temperature probe was used to measure tissue temperatures. Tumor and background liver without exposure to NIR were also assayed as controls. Samples were prepared for assessment of ROS generation with fluorescence microscopy, using DAPI staining as a control.

Results: Nanoparticles selectively accumulated within viable portions of tumor as seen by NIR. Necrotic portions of tumor did not accumulate nanoparticles, consistent with a vascular distribution. NIR-dependent heat generation was observed with nanoparticle-containing tumors, but not in background liver. No heat was generated in the absence of NIR laser light. ROS generation was seen in nanoparticle-containing tumors exposed to NIR, but not in background liver exposed to NIR or in tumors not exposed to NIR.

Conclusions: In this pilot study, biodegradable nanoparticle delivery to solid organ tumors from a transarterial approach enabled selective in vivo tumor imaging and combinatorial phototherapy. This has implications for theranostics, tumor detection, and selective therapy to increase the scope of percutaneous solid organ tumor treatments while minimizing associated toxicity. Optimization of this strategy will be the goal of subsequent research.
**Purpose:** To demonstrate feasibility of Magnetic Resonance Navigation (MRN) as a treatment for non-resectable HCC, which consists in steering magnetic drug-eluting microbeads (MDEBs) in hepatic arteries towards diseased liver lobes using a clinical MRI machine, with regards to physiological, anatomical and technological limitations.

**Materials:** In the first phase, in vivo experiments were performed on pig models to characterize the efficiency of arterial flow reduction using a balloon catheter and the reliability of flow measurement methods. Cine phase-contrast imaging was performed on the proper hepatic artery of eight pigs, with a balloon catheter, positioned upstream, both inflated and deflated. Four pigs had a liver lobe embolized using radiopaque microbeads. In the second phase, in vitro proof-of-concept MRN experiments were performed to demonstrate the feasibility of using a custom gradient sequence on an unmodified MRI machine (Siemens, Germany) to selectively steer MDEB boluses of controlled size in a one-bifurcation arterial system.

**Results:** In the first phase, cine-phase-contrast imaging on one-lobed embolized pigs revealed that the use of a balloon catheter, combined with a 0.5 ml/s saline injection, decreased the average flow velocity from 13.6 ± 2.0 cm/s to 5.4 ± 3.0 cm/s. For unembolized pigs [respectively one-lobed embolized], the systolic-diastolic flow variation was decreased from 24.0 ± 14 cm/s to 4.9 ± 2.3 cm/s [from 14.9 ± 1.4 cm/s to 3.3 ± 2.2 cm/s] (p<0.05 in all cases). In the second phase, we obtain different (p<0.0001) right/left bolus steering ratios of 22.5% when applying a 20 mT/m gradient towards the left and 67.5% when applying a 20 mT/m gradient towards the right, resulting in an overall steering efficiency of 72.5% (different from the 50% baseline, p<0.0001).

**Conclusions:** This study shows that the use of a balloon catheter reduces arterial hepatic flow magnitude and variation.

---

**3:27 PM Abstract No. 315**

**Radiopaque in situ forming implant (RISFI): a novel phase sensitive, biodegradable embolic for endovascular embolization and drug-delivery**

H. Wu¹, S. Jeganathan², A. Exner², S. Tavri¹; ¹University Hospitals Cleveland Medical Center, Cleveland, OH; ²Case Western Reserve University, Cleveland, OH

**Purpose:** In situ forming implants (ISFI) consist of a biodegradable polymer dissolved in an organic solvent which can be mixed with a therapeutic agent creating a liquid solution. Upon injection into an aqueous environment, the ISFI undergoes phase inversion from liquid to solid state due to solvent/nonsolvent mass transfer creating a drug-eluting depot at the target site. In this study, we describe the development of a radiopaque ISFI (RISFI) and its in vivo flow dynamics and occlusive effects via portal vein administration in rats; and compare it to commercially available radiopaque beads (RBs).

**Materials:** RISFI were comprised of poly(lactic-co-glycolide) (PLGA), the solvents N-methyl pyrrolidone (NMP) and benzyl benzoate (BB), and the iodinated contrast agent (Ioversol). Direct portal vein injection of RISFI (n = 10) or RBs in Ioversol (n = 9) was performed in Sprague Dawley rats. The animals were euthanized at 2 hours, 24 hours and 7 days post embolization. Explanted livers were evaluated with microCT to confirm the radiopacity of the RISFI formulation and pathology to examine the embolic effects.

**Results:** MicroCT images of explanted livers demonstrate RISFI has similar radiopacity compared to RB. On microCT images, in 9 rats embolized with RBs, 4 showed scattered bead distribution, 5 showed peripheral portal vein branch dominant localization. The ISFI deposit was seen in both peripheral and central portal vein branches. Macroscopic and histologic analysis showed that periportal vein necrosis was seen primarily in the RISFI group and reached the peak at 24h. At day 7, moderate to severe liver hypotrophy was noted in RISFI group. However minimal nonspecific necrosis and no significant atrophy were seen in the RB group over time.

**Conclusions:** This study shows successful preliminary development of RISFI and the feasibility for its portal vein administration and superior pathologic effects in a normal rat liver when compared to RBs. Intra-arterial embolization on tumor bearing rat liver and mechanistic investigation of the mechanism responsible for the observed effects will be performed in the future.
Developing TACE 2.0: targeting hepatocellular carcinoma epigenetic and ischemia survival pathways

M. Silk, J. Benjamin, D. Ackerman, M. Noji, G. Nadolski, S. Hunt, T. Gade; University of Pennsylvania, Philadelphia, PA; PIGI Lab, Philadelphia, PA; Penn Image-Guided Interventions Lab, Philadelphia, PA; Hospital of the University of Pennsylvania, Philadelphia, PA

Purpose: Epigenetic alterations in hepatocellular carcinoma (HCC) may facilitate cell survival under transarterial chemoembolization-induced ischemia by potentiating the function of canonical stress response pathways including the unfolded protein response (UPR), Hypoxia-Inducible Factor (HIF), and Autophagy. Moreover, the redundancy in function of these pathways makes inhibition of any single pathway insufficient to abrogate their function entirely. We hypothesize that HCC cells surviving severe TACE-like ischemia are susceptible to inhibition of these pathways and that combination of the inhibition of these pathways would lead to synergistic effects.

Materials: Viability assays and cytotoxicity profiles of Huh-7, SNU-387 and SNU-449 HCC cell lines were studied under standard conditions (21% O2 with complete medium) and compared to severely ischemic conditions (1% O2, 1% serum, 1 mM glucose) with an inhibitor of the UPR (GSK2606141), a HIF-1 alpha inhibitor (PX-478 or BAY87-2243) and an inhibitor of autophagy (Hydroxychloroquine). Cytotoxicity measurements were derived from measured dose-response curves using the WST-1 cytotoxicity assay. The t-test was used to compare standard to severely ischemic conditions.

Results: Each of the cell lines tested demonstrated decreased cellular viability with incubation of either of the inhibitory agents (EC50 GSK2606141, PX-478, BAY87-2243, Hydroxychloroquine of 75-150μM, 50-100 μM, 300-600μM, and 100-200μM respectively). Ischemia potentiated the cytotoxicity (EC50 GSK2606141, PX-478, BAY87-2243, Hydroxychloroquine of 25-50μM, 50-75 μM, 200-400μM, and 50-80μM respectively; with p<0.05 except for BAY87-2243). Combination inhibition of the three pathways under TACE-like ischemia lead to a synergistic response showing cell death at concentrations below any single drug alone (EC50 of BAY87-2243 in combination of 100-200μM compared to 400-500μM as a single agent).

Conclusions: Inhibition of the UPR, HIF, and autophagy independently lead to cytotoxicity of HCC cells. Combination of the three drugs under TACE-like ischemia lead to a synergistic response and should be considered as potential chemotherapeutics for TACE.

Thermoresponsive Nanonet as a carrier for transarterial immunomodulatory chemoembolization: an experimental study for rabbit liver cancer model

S. Lee, T. Van Ha, L. Yassan, J. Hart, A. Ostdiek, Y. Zhu, S. Yi, E. Scott, G. Ameer; The University of Chicago, Chicago, IL; University of Chicago, Chicago, IL; Northwestern University, Evanston, IL

Purpose: Poly (polyethylene glycol citrate-co-N-isopropylacrylamide) is referred to thermoresponsive nanonets that are liquid at room temperature and become a gel at physiologic temperature. Our purpose is to assess whether thermoresponsive nanonets are suitable biocarrier for transarterial Immunomodulatory chemoembolization to treat vascular malignant tumors.

Materials: The Poly was mixed with iodixanol to provide radio-opacity (poly-iodixanol). Poly(ethylene glycol)-bl-poly(isopropylene sulfide) (PEG-bl-PPS) nanocarriers were stably loaded with immunostimulant imiquimod (TLR7 agonist). Subsequently, doxorubicin and imiquimod-loaded nanocarriers (IM-NC) were added to the poly-iodixanol to synthesize immunomodulatory chemoembolization Nanonet (ICE-Nanonet). VX-2 tumor was directly implanted into the rabbit liver via laparotomy and was monitored with ultrasound. When the tumor reached about 2 cm, transarterial embolization was performed using; Saline only (Gr.1), Poly only (Gr.2) or ICE-Nanonet (Gr.3). Animals were euthanized at either one or 2 weeks after transarterial embolization. Histopathologic categorization was performed based on the distribution pattern of viable tumor cells and tumor necrosis: Cat A as peripheral viable tumor cells with central necrosis and Cat B as tumor necrosis seen at both central and periphery of tumor mass.

Results: Sixteen animals [Gr.1 (n = 4), Gr.2 (n = 2) and Gr.3 (n = 10)] that had successful liver tumor implantation and embolization were included. Histopathological examinations were performed in 2, 2, and 7 animals in Gr.1, Gr.2, and Gr.3, respectively. Viable tumor cells were seen in all specimens. Cat.A pattern was seen in all Gr.1 (100%, n = 2/2), 50% in Gr.2 (n = 1/2) and 14.3% in Gr.3 (n = 1/7). Cat.B pattern was seen in 85.7% in Gr.3 (n = 6/7), 50% in Gr.2 (n = 1/2) and no animal showed Cat.B pattern in Gr.1.

Conclusions: Immunomodulatory chemoembolization using nanonet compound is feasible and appears to have preliminary efficacy over control in this pilot study. Using poly-dependent embolization for localized sustained delivery of immunomodulatory nanotherapeutics may have future potential for initiating additional tumor control in the rabbit liver cancer model.

Preclinical fluoroscopic-guided delivery of a novel nanotherapy in a rat model of hepatocellular carcinoma

P. Sutphin, J. Li, R. Brown, I. Corbin; UT Southwestern Medical Center, Dallas, TX

Purpose: To investigate the anti-tumor activity of low-density lipoprotein docosahexaenoic acid nanoparticles (LDL-DHA) administered via transarterial catheter-based delivery to hepatocellular carcinoma in the rat.

Materials: Orthotopic N1-S1 rat hepatoma cells (5 x 10^6 cells) were implanted into the liver of Sprague-Dawley rats.
Tumor-bearing rats were then treated with a single locoregional dose of 2 mg/kg of LDL-DHA nanoparticles via transcatheter catheter-based delivery. Three days following LDL-DHA treatment or sham procedure, histologic examination was performed to assess antitumor effects. Oxidative stress was examined as a potential mechanism for LDL-DHA tumor cytotoxicity through in vitro studies. N1-S1 rat hepatoma cells were treated with LDL-DHA and examined for oxidative stress with dihydroethidium fluorescence and thiobarbituric acid reactive species assays.

**Results:** Histologic examination of sham-treated and LDL-DHA tumors demonstrated LDL-DHA-induced necrosis in tumor specimens without injury to the adjacent normal liver. In vitro studies to examine for reactive oxygen species demonstrate increased oxidative stress in tumor cells (N1-S1) following treatment with LDL-DHA, but not in control treatments.

**Conclusions:** Fluoroscopic catheter-based transarterial delivery of LDL-DHA nanoparticles is a feasible approach that more faithfully reflects the treatment strategy used in humans. The mechanism of tumor toxicity is related to disruption of the redox balance within tumor cells.

**Development and use of the common woodchuck as a model for treatment of hepatocellular carcinoma**

W. Pritchard1, D. Woods1, S. Leonard2, J. Esparza-Trujillo1, I. Bakhathashvili3, A. Mikhail1, E. Levy2, V. Krishnasamy3, J. Karanian1, B. Wood4; 1National Institutes of Health, Bethesda, MD; 2NIH, Bethesda, MD; 3National Institutes of Health, Arlington, VA; 4National Institutes of Health, North Bethesda, MD

**Purpose:** Define the utility of woodchucks as a model for development and evaluation of image-guided interventional therapies for the treatment of primary hepatocellular carcinoma (HCC).

**Materials:** All studies were conducted under a research protocol approved by the Institutional Animal Care and Use Committee. Woodchuck chronically infected with woodchuck hepatitis virus (WHV) develop neoplasms similar to human HCCs associated with hepatitis B. Woodchucks with and without HCC underwent preoperative CT and US. A 3F introducer sheath was placed in the femoral artery and diagnostic angiography performed via 1.7-2.8F microcatheters. Following superselective catheterization, embolization of arteries supplying HCC tumors was performed to stasis with radiopaque beads on CBCT, microCT and specimen radiography. Histology showed beads present within the vasculature.

**Conclusions:** These data may help guide future studies of HCC therapies. Additional research is needed to refine the methods and validate the model; however, a more predictive HCC model than previously described would be valuable for translational medical research.

**Analysis of in vivo tumor growth kinetics in a diethylnitrosamine-induced, transarterial embolization-treated rat model of hepatocellular carcinoma**

R. Kiefer1, E. Profka1, M. Pourfathi1, G. Nadolski1, S. Hunt2, T. Gade3; 1University of Pennsylvania, Philadelphia, PA; 2Penn Image-Guided Interventions Lab, Philadelphia, PA; 3Hospital of the University of Pennsylvania, Philadelphia, PA

**Purpose:** The use of diethylnitrosamine (DEN) to induce hepatocellular carcinoma (HCC) in rats is well established. Previous work has demonstrated consistent progression of liver fibrosis and carcinogenesis, but data regarding in vivo tumor growth is lacking. Furthermore, evaluation of tumor behavior following transarterial embolization (TAE) in a rat model is incompletely described in the literature. The purpose of this study was to analyze tumor growth kinetics before and after TAE using clinical imaging criteria.

**Materials:** Forty-eight male Wistar rats were fed 0.01% DEN in water ad lib for 12 weeks to induce HCC. Then, T2-weighted MRI was performed once per week to evaluate tumors over time. Dynamic contrast enhancement studies were performed in 8 rats. Using LI-RADS v2017 criteria, tumors were evaluated for arterial phase hyperenhancement (APHE) and delayed phase washout as well as tumor growth. Twelve rats with threshold tumor size were treated with selective TAE, after which rats underwent follow-up imaging on posttreatment days 4, 7, and 14. Four rats with matched tumor size were used as controls on matched days. Tumor volume rendering was performed from MRI data with ITK-Snap software.

**Results:** All rats developed radiographic evidence of HCC, which was histologically confirmed with H&E staining. Tumors were found to have an average growth of 30 mm3/day prior to embolization. In treated rats, tumor growth was found to regress at a rate of -11 mm3/day immediately following embolization, whereas tumor growth kinetics were unchanged throughout the study interval in control rats. APHE of tumors was found to be on average 160% of surrounding liver intensity prior to treatment and delayed phase washout was confirmed with 75% intensity. Following embolization, arterial phase hyperenhancement tumors was found to be 55% of surrounding liver intensity.
Conclusions: The DEN rat model of HCC accurately reflects some of the diagnostic features observed clinically. Furthermore, clinical criteria are useful in the assessment of intervention in this model. The establishment of tumor growth kinetics in this model is useful for future studies of treatment response.

4:21 PM  Abstract No. 321

Transforming growth factor-β1 blockade after irreversible electroporation of murine urothelial tumor does not provide additional survival or cancer control benefits

M. Fujimori1, L. Vroomen2, E. Ueshima3, K. Kim1, K. Nagar1, J. Coleman1, G. Srimathveeravalli4; 1Memorial Sloan Kettering Cancer Center, New York, NY; 2VU University Medical Center, Amsterdam, NH; 3Kobe University, Kobe, Hyogo; 4Memorial Sloan Kettering Cancer Center, Kew Gardens, NY

Purpose: Transforming growth factor-β1 (TGF-β1) mediated epithelial to mesenchymal transition (EMT) in urothelial tumors can contribute to escape from sub-lethal ablation and increase distant metastases. This study investigated the outcomes of TGF-β1 blockade with Pirfenidone (PFD) following ablation murine urothelial tumors with irreversible electroporation (IRE).

Materials: Murine urothelial carcinoma cells (MB49) were used to evaluate the effects of TGF-β1 (5ng/ml) with or without PFD (1 mM) on cell proliferation (MTT assay), TGF-β1 secretion, migration (wound scratch assay) and transwell invasion in vitro. Forty mice were implanted with subcutaneous flank MB49 tumors were randomly divided to receive 1: Sham treatment. 2: IRE. 3: PFD or 4: IRE+PFD. IRE (2000V/cm, 90pulses, 100 microsecond, 1Hz) was performed using non-invasive caliper electrodes. Intrapерitoneal PFD (200 mg/kg) was administered on alternate days after IRE. Local tumor measurements, lung metastases burden (bioluminescent imaging and histology) and overall survival were measured.

Results: PFD inhibited the proliferation (p<0.05) but not secretion of TGF-β1 by MB49 cells in vitro. TGF-β1 promoted cell migration on wound scratch and invasion assays (p = 0.04), and PFD treatment inhibited these effects (p<0.004). TGF-β1 induced a spindle cell morphology in MB49 cells which was reversed with PFD treatment. Compared to control, both IRE and IRE+PFD had smaller tumor volumes (p<0.001) but there was no difference in tumor volume between IRE and IRE+PFD groups. PFD monotherapy had no effect on tumor growth (p = 0.288). There was no difference in survival of animals when comparing control, PFD and PFD+IRE groups. Compared to controls, mice treated with IRE monotherapy survived the longest (p = 0.0004). Quantification of lung metastases with imaging and pathology did not reveal any difference in distant tumor burden between the four cohorts.

Conclusions: PFD effectively inhibited the TGF-β1 mediated cell migration, invasion and proliferation in vitro. Combination treatment with PFD and IRE did not provide additional local tumor control or survival benefit in mice.

3:00 PM  Abstract No. 322

Outcomes after transarterial embolization versus radioembolization of neuroendocrine tumor liver metastases

R. Zener1, H. Yoon1, E. Ziv1, A. Covey1, K. Brown1, C. Sofocleous1, R. Thornton1, F. Boas1; 1Memorial Sloan Kettering Cancer Center, New York, NY

Purpose: To evaluate initial response and overall survival (OS) of neuroendocrine tumor (NET) liver metastases initially treated with transarterial embolization (TAE) versus radioembolization (RE).

Materials: An IRB-approved retrospective review was performed of 174 patients with NET liver metastases initially treated with TAE (n = 159) versus RE (n = 15). For each patient, we evaluated: initial response by mRECIST, overall survival after initial locoregional therapy, primary site (lung, pancreas, small bowel, or other), degree of differentiation, Charlson comorbidity index, Child Pugh score, ECOG performance status, TAE particle size, angiographic evidence of arteriovenous shunting, whether an extrahepatic vessel was embolized during the initial treatment, presence of extrahepatic tumor, volume of liver disease, degree of selectivity of the embolization, presence of NET-related symptoms, and urgency of the initial procedure.

Results: There was no difference in initial response for NET treated with TAE versus RE (53% vs 60% CR or PR, p = 0.79). Initial response was higher for TAE using particles <100 μM versus TAE using only particles ≥100 μM (64% vs 42%, p = 0.01). Multivariate logistic regression showed that use of particles <100 μM, small bowel NET, and liver <50% replaced with tumor were independent predictors of a better initial response rate. Median OS after initial locoregional therapy was 55 months for TAE and 16 months for RE (p = 0.04). There was no significant difference in survival between TAE patients treated with <100 μM versus only ≥100 μM particles. Multivariate Cox proportional hazards model showed that initial treatment using TAE, well differentiated NET, no arteriovenous shunt on angiography, liver <50% replaced by tumor, and selective embolization were independent predictors of improved OS.

Conclusions: NET patients treated with TAE have the same initial response, but increased overall survival, compared to RE. NET patients treated with TAE using particles <100 μM had better initial response, but the same overall survival, compared to TAE using only particles ≥100 μM.
Locoregional therapy and systemic chemotherapy versus systemic chemotherapy on outcome for intrahepatic cholangiocarcinoma

C. Sellers1, J. Ludwig1, J. Uhlig1, S. Stein1, J. Lacy1, H. Kim1; 1Yale School of Medicine, New Haven, CT

Purpose: To investigate the impact of locoregional therapy (LRT) and systemic chemotherapy on outcome for treatment of intrahepatic cholangiocarcinoma (ICC) in a tertiary care hospital.

Materials: Consecutive patients diagnosed with ICC between 2005 and 2016 in the cancer registry were studied. Patients were stratified by treatment course. Kaplan-Meier curves and Cox proportional hazard models were performed.

Results: 80% received systemic chemotherapy (78 patients), including gemcitabine/cisplatin. 9% had LRT (9 patients), and 11% had combined LRT and chemotherapy (11 patients). Patients were similarly distributed by age, gender, ethnicity, comorbidities, and AJCC stage. Median overall survival (OS) from initial diagnosis demonstrated 18.1 mo (95% CI 5.6-33.1 mo) for LRT + systemic therapy patients vs 10.8 mo (95% CI 7.9-13.5) for systemic patients (p = 0.0321). LRT patients had a median OS of 10.7 mo (95% CI 0.6-not reached) vs systemic patients (p = 0.067). Median OS calculated from date of first treatment showed a survival benefit for LRT + systemic therapy (median OS 17.3 mo, 95% CI 7.3-13.9) vs systemic (median OS 10.0 mo, 95% CI 5.8-12.6 mo) (p = 0.045). LRT patients had a median OS of 7.9 mo (95% CI 0.6-not reached) vs systemic (p = 0.065). Survival from date of first systemic or first LRT demonstrated a median OS of 17.3 mo (95% CI 3.2-26.5 mo) for LRT + systemic therapy patients vs 10.0 months (95% CI 5.8-12.6 mo) for systemic patients (p = 0.445). Median OS in LRT (7.9 mo, 95% CI 0.6-not reached) was comparable to chemotherapy (p = 0.07). Mean time from diagnosis to the 1st LRT was 169 days (SD 145 days) for LRT + systemic therapy patients vs 47 days (SD 43) to the 1st LRT for LRT patients vs 42 days (SD 29) to the 1st systemic for systemic patients (p=0.0001). The mean time from systemic to LRT in LRT + systemic patients who received systemic prior to LRT was 118 days (SD 152 days). Multivariate analysis after adjusting for AJCC stage and comorbidities demonstrated a survival benefit for LRT + systemic therapy versus systemic (HR 0.34, 95% CI 0.01-0.86, p = 0.0204).

Conclusions: LRT + systemic leads to improved survival versus systemic alone in ICC.

Genetic heterogeneity across tumor specimens in patients with neuroendocrine liver metastases

E. Ziv1, F. Boas1, H. Yarmohammadi2, S. Solomon2, J. Erinjeri2; 1Memorial Sloan Kettering Cancer Center, New York, NY; 2Memorial Sloan-Kettering Cancer Center, New York, NY; 3Memorial Sloan Kettering Cancer Center, New York, NY

Purpose: To characterize the intra-individual genetic heterogeneity of patients with neuroendocrine tumor liver metastases (NLM) undergoing transarterial embolization (TAE).

Materials: An IRB-approved retrospective review was performed of patients with NLM treated with TAE from 2014-2017 to identify patients who had gene mutation analysis from multiple tumor specimens from two or more sites. For each patient we identified date, time and location of the specimen and pathological tumor grade. Gene mutations and copy number aberrations were recorded for 341 “actionable” genes using a hybridization capture-based next-generation sequencing assay.
**Results:** We identified 17 tumor specimens from 7 patients that underwent mutational analysis (4 patients had specimens from two sites analyzed and 3 patients had specimens from 3 sites analyzed). The average time between tissue specimens was 3.8 years (range, 0.6-11.3 years). Tissue specimens were from the primary site (n = 3), liver metastasis (n = 13) and an abdominal wall metastasis (n = 1). Tumor grade changed between tumor specimens in 8/10 cases, increased in 6/10 cases, and decreased in 2/10 cases. The number of mutations increased in 7/10 cases, decreased in 2/10 cases, and stayed the same in one case. In 1/10 cases the mutation status did not change between specimens. MEN1 (12/17), DAXX (11/17), PTEN (6/17), and SETD2 (5/17) were the most common mutations observed. All MEN1 mutations were stable (unchanged) across specimens; one of four patients with a DAXX mutation, acquired the mutation between specimens. Of the 4 patients with PTEN mutations, 2 lost the mutation, 1 gained a second PTEN mutation, and one did not change. Of the 3 patients with SETD2 mutations, 2 gained mutations and 1 did not change.

**Conclusions:** There is marked heterogeneity between tumor specimens in patients with NLM undergoing TAE. Future studies will investigate whether mutations with greater variability across specimens represent later events in tumorigenesis.

---

**3:36 PM Abstract No. 326**

**Balloon-occluded transarterial chemoembolization (B-TACE): single-center U.S. experience**

M. Singh1, E. Kim2, R. Patel1, F. Nowakowski2, R. Lookstein1, M. Ranade1, V. Bishay3, A. Fischman4; 1Mount Sinai Hospital, New York, NY; 2Mount Sinai Medical Center, New York, NY; 3Icahn School of Medicine at Mount Sinai Hospital, New York, NY; 4Icahn School of Medicine at Mount Sinai, New York, NY

**Purpose:** Balloon-occluded transarterial chemoembolization (B-TACE) may be potentially advantageous in the treatment of liver malignancy. This technique alters flow-dynamics ideally allowing deeper penetration of therapeutic agents. We describe our single-center experience involving balloon occlusion for liver directed therapy.

**Materials:** Retrospective analysis was performed from 9/2016 to 5/2017 in which 24 lesions in 22 patients (20 males, 2 females, age range 51-90) underwent liver directed therapy utilizing a balloon occluding microcatheter (Scepter C (Microvention) [n = 16] or Sniper (Embolx) [n = 8]) for therapeutic embolization of hepatocellular carcinoma. Patients underwent balloon occlusion for conventional TACE (50%) and DEB-TACE (50%). Target lesion response was evaluated using Modified Response Evaluation Criteria for Solid Tumors (mRECIST) using contrast enhance CT or MRI. Technical success, patient demographics, lesion characteristics, lab values and adverse events (AEs) were recorded.

**Results:** Technical success was 100%. Mean follow-up time was 4 months (range, of 1-17 months). Of patients who did not undergo subsequent thermal ablation (10/24), target lesions were analyzed utilizing mRECIST criteria. Mean lesion diameter was 2.7 cm (range1.1-5.9). Disease control rate was 100%. Objective response was 90%. 60% (6/10) demonstrated a complete response, 30% (3/10) demonstrated partial response, 10% (1/10) had stable disease on follow-up. No patients demonstrated progression of disease at follow-up. There were no intra-procedural AEs. At 4 weeks one patient had a 1.3 cm liver infarct and new portal vein thrombosis. Statistical analysis of serum biochemistry demonstrated no significant difference in pre- vs post-procedure parameters.

**Conclusions:** B-TACE is a feasible technique with favorable safety profile. Our small subset of patients demonstrated good outcomes, but findings warrant further investigation with direct comparison to conventional therapies.

---

**3:45 PM Abstract No. 327**

**Survival analysis and initial imaging response of conventional transarterial chemoembolization versus drug-eluting embolic transarterial chemoembolization for unresectable hepatocellular carcinoma**

N. Martinez1, E. Bravo1, T. Cermenati1, B. Leon1, J. Bravo1, J. De Gracia1, C. Moya1, J. Weisz1, P. Palavecino1; 1University of Chile, Santiago, Chile

**Purpose:** To compare the survival and initial imaging response of conventional transarterial chemoembolization (TACE) performed with a mixture of lipiodol with Doxorubicin followed by microspheres embolization (cTACE) versus drug-eluting embolic transarterial chemoembolization loaded with Doxorubicin (DEE-TACE) for the treatment of unresectable hepatocellular carcinoma (HCC).

**Materials:** Retrospective single-center study, with consecutive patients who underwent TACE for unresectable HCC from January 2005 to December 2016. Patients who received contemporary adjuvant treatment (radiofrequency, microwave or alcoholization) were excluded. Variables analyzed were gender, age, etiology of chronic liver disease, MELD-Na score, Child-Pugh classification, size, location and number of HCC, diameter of the larger HCC and number of TACE sessions. The primary endpoint was survival, measured as time from first TACE to death. Secondary endpoint was imaging response to TACE, assessed using modified response evaluation criteria in solid tumors (mRECIST), which classifies patients in complete response (CR), partial response (PR), stable disease (SD) or progressive disease (PD). Statistical analysis was performed using t-test for continuous variables and chi2 for categorical variables, the survival rates were calculated by Kaplan–Meier method and survival curves were compared using log-rank test. A value of p <0.05 was considered statistically significant.
Results: 109 patients underwent TACE, 79 received cTACE and 30 DEB-TACE. Significant differences between both groups were observed in the number of TACE sessions (higher in cTACE group, p = 0.035), Survival at 1, 2- and 3-years were 67%, 34% and 27% for cTACE group and 72%, 64% and 64% for DEE-TACE group, respectively (p = 0.113). After treatment, CR, PR, SD and PD were 29 (33%), 11 (20%), 12 (22%) and 3 (5%) for cTACE group, and 10 (44%), 9 (39%), 4 (17%) and 0 for DEE-TACE group, respectively (p = 0.299).

Conclusions: No significant differences in terms of survival or initial imaging response between cTACE and DEE-TACE were observed in the present study. However, there is a tendency for a higher survival rate in DEE-TACE group.

3:54 PM Abstract No. 328

Aspirin is associated with lower bilirubin after embolization of hepatocellular carcinoma

F. Boas1, K. Brown1, E. Ziv1, H. Yarmohammadi1, J. Ernjeni1, C. Sofocleous1, J. Harding1, S. Solomon1; 1Memorial Sloan Kettering Cancer Center, New York, NY

Purpose: In retrospective studies, aspirin is associated with improved survival when combined with TACE or TAE for HCC. However, the mechanism is unclear.

Materials: An IRB-approved retrospective review was performed of 304 patients with HCC who were treated with TAE. The patients were divided into two groups, based on whether the patient took aspirin (n = 42) or did not take aspirin (n = 262) at the time of initial TAE. For each patient, the following information was collected: response of embolized tumors (mRECIST, 1 month post embolization), time-to-progression after initial embolization, initial site of progression (treated tumor, untreated liver tumor, or extrahepatic tumor), survival, and bilirubin pre- and post-embolization. Kaplan-Meier curves were compared using the log rank test. Proportions were compared using Fisher’s exact test. Bilirubin was compared using two-tailed t-tests.

Results: Patients taking aspirin versus not taking aspirin at the time of initial TAE for HCC had no difference in: initial response rate (88% vs 90% CR or PR, p = 0.59), median time-to-progression (6.2 mo vs 5.2 mo, p = 0.42), initial site of progression (p = 0.77), and fraction of patients dying with disease progression on imaging (88% vs 89%, p = 1). Prior to embolization, there was no difference in average bilirubin (0.8 vs 0.9, p = 0.11) or numerical Child Pugh score (5.5 vs 5.5, p = 0.65) for patients taking versus not taking aspirin. After embolization, bilirubin was significantly lower for patients taking aspirin, at 1 day (0.9 vs 1.3, p<0.001), 1 month (0.9 vs 1.2, p = 0.048), and 1 year (0.8 vs 1.0, p = 0.021) post-procedure. Median overall survival after initial embolization was higher for patients taking aspirin (57 vs 23 months, p = 0.008).

Conclusions: Aspirin is associated with lower bilirubin and improved survival after TAE for HCC. It is not associated with any differences in response or time-to-progression.

Table 1. Baseline Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total records (n = 520)</th>
<th>FD group (n = 284)</th>
<th>SHD Group (n = 236)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>≥65(n/%)</td>
<td>169(32.5%)</td>
<td>92(32.4%)</td>
<td>77(32.6%)</td>
</tr>
<tr>
<td></td>
<td>&lt;65(n/%)</td>
<td>351(67.5%)</td>
<td>192(67.6%)</td>
<td>159(67.4%)</td>
</tr>
<tr>
<td>Gender</td>
<td>Male (n/%)</td>
<td>425(81.7%)</td>
<td>230(81.0%)</td>
<td>196(82.6%)</td>
</tr>
<tr>
<td></td>
<td>Female (n/%)</td>
<td>95(18.3%)</td>
<td>54(19.0%)</td>
<td>41(17.4%)</td>
</tr>
</tbody>
</table>

4:03 PM Abstract No. 329

Comprehensive analysis of common safety profiles and their predictive factors in 520 records of liver cancer patients treated by drug-eluting beads transarterial chemoembolization

G. Zhou1, Y. Zhang1, T. Zhou1, T. Zhu1, J. Sun1; 1The First Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang Province

Purpose: To investigate the difference of common AEs between patients who experienced first DEB-TACE (FD) and patients who experienced second or higher DEB-TACE (SHD), and further explore the factors influencing AEs.

Materials: 520 records of DEB-TACE operation were retrospective reviewed in this cohort study, among which 284 records were in FD group and 236 records were in SHD group. The incidence and/or severity of pain, fever, vomiting and increased blood pressure were collected.

Results: Pain NRS score (P = 0.002), pain severity (P = 0.027), body temperature (P<0.001), fever severity (P = 0.014), and fever lasting days (P = 0.002) were all higher in FD group compared with SHD group, while no differences of vomiting (P = 0.517) and increased blood pressure (P = 0.248) between two groups were disclosed. Besides, Age≥65 years was associated with increased high fever (P = 0.022) and lower possibility of vomiting (P = 0.004) in FD group, as well as lower pain severity (P = 0.042) and less fever severity (P = 0.033) in SHD group; Male decreased the possibility of vomiting in both FD group (P = 0.002) and SHD group (P = 0.001), and reduced the possibility of increased blood pressure in SHD group (P = 0.040); diabetes history was correlated with decreased pain degree (P = 0.021) and less fever (P = 0.040) in FD group.

Conclusions: In conclusion, SHD was better tolerated compared to FD in liver cancer patients, and older age as well as male were correlated with less occurrence or severity of common AEs in DEB-TACE operation.
**4:12 PM Abstract No. 330**

**Analgesic and antiemetic requirement for post-embolization syndrome after cTACE versus DEB-TACE**

M. Khalaf1, M. AbdelRazek1, D. Wang1, R. Shah1, N. Kothary1; 1Stanford University Medical Center, Stanford, CA

**Purpose:** To compare the analgesic and antiemetic requirements after transarterial chemoembolization with doxorubicin eluting microspheres (DEB-TACE) versus conventional chemoembolization (cTACE) in patients with hepatocellular carcinoma (HCC).

**Materials:** Between 2014-2016, 283 patients (mean age 66 y, 72% male) underwent 395 super-selective TACE procedures (189 cTACE, 206 DEB-TACE) for HCC within UCSF criteria. cTACE was performed using 5 mg/mL doxorubicin emulsified with ethiodized oil for a maximum dose of 50 mg and DEB-TACE was performed with 100-300 μm spheres impregnated with 150 mg of doxorubicin (LC beads, BTG, UK). Patients were retrospectively reviewed for tumor characteristics, procedural technique, prior therapies and chronic pain. Postoperative (within 6 h post-TACE) and overnight use of intravenous and oral analgesics and antiemetic agents was assessed.

**Results:** Baseline demographics, Child-Pugh scores, prior therapies and chronic pain history were similar between both groups. Median tumor diameter for cTACE was 2.2 cm (mean 2.5 cm, SD 1.2 cm) and was 2.4 cm for DEB-TACE (mean 2.9 cm, SD 1.4 cm). Delivered doxorubicin dose was higher with DEB-TACE than with cTACE (55.2 mg vs 29.6 mg, p = 0.0001). While the need for intravenous analgesia and antiemetic agents was similar for both groups in the postoperative period (p = 0.3), a higher percentage of patients treated with DEB-TACE required overnight intravenous analgesia and antiemetics (23% vs 11% cTACE, p = 0.002), increasing the overall utilization of intravenous drugs in the DEB-TACE group (p = 0.04). Requirements for oral narcotic analgesia were also higher following DEB-TACE compared to cTACE (56% vs 43%, p = 0.01). Delivered doxorubicin dose and nausea were correlated (p = 0.016) and thus resulted in increased requirements for antiemetic agents following DEB-TACE (25% vs 16% for cTACE, p = 0.04).

**Conclusions:** Patients undergoing DEB-TACE require more post procedural analgesia and antiemetic agents compared to cTACE. Postprocedural care should be planned accordingly to ensure patient comfort especially when considering same-day discharge.

---

**4:21 PM Abstract No. 331**

**Quantitative analysis of Lipiodol washout rates in intrahepatic cholangiocarcinoma and hepatic metastasis from neuroendocrine tumors and colorectal cancer after chemoembolization**

N. Nezami1, M. Van Breugel2, M. Miszczuk3, I. Rexha4, A. Windham-Herman3, L. Savic3, N. Murali3, M. Lin4, J. Chapiron5, J. Geschwin6; 1Yale University School of Medicine, Hamden, CT; 2N/A, New Haven, CT; 3Yale School of Medicine, New Haven, CT; 4Yale University School of Medicine, New Haven, CT; 5Yale University School of Medicine, New Haven, CT; 6PreScience Labs/ Cage Pharma, Westport, CT

**Purpose:** To evaluate Lipiodol washout time after conventional transarteral chemoembolization (cTACE) in different hepatic malignancies including intrahepatic cholangiocarcinoma (ICC) as well as hepatic metastatic neuroendocrine tumors (NET) and colorectal carcinoma (CRC).

**Materials:** This retrospective study included 41 patients, who underwent cTACE for the treatment of ICC (n = 9), NET (n = 14) or CRC metastases to the liver (n = 12). Lipiodol volume (LV) in cm³ was analyzed on follow-up non-contrast CT imaging obtained within 24 hours (LV1) as well as 40-220 days (LV2) after cTACE using a volumetric segmentation and image analysis software (qEASL; Medisys, Philips Research, Suresnes, France). The Lipiodol washout rate was calculated as the ratio of (LV1-LV 2) to the interval (in days) between both CT scans. Additionally, tumor response on contrast-enhanced MRI was assessed 1 month after cTACE according to qEASL criteria.

**Results:** Lipiodol was visible on all follow-up CT scans. The LV2 was significantly lower than LV1 in all three tumors types (p < 0.001). The mean lipiodol washout rate was -0.034 for ICC, -0.045 for NET, and -0.034 cm³/day for CRC metastases. No significant difference in lipiodol washout rates was observed between the three types of tumors (p > 0.05). As for tumor response, 2/9 ICC patients, 4/14 NET patients and 5/18 CRC patients demonstrated response to cTACE according to qEASL criteria. However, no difference in lipiodol washout rate was revealed between responders and non-responders (p > 0.05).

**Conclusions:** This study showed that lipiodol washout rates after cTACE were similar for different hepatic malignancies including ICC, NET and CRC metastases. All observed tumors showed consistent washout regardless of response suggesting that lipiodol washout rate may not be predictive of tumor response to treatment.

---

**Scientific Session 34**

**Ablation: Miscellaneous**

Wednesday, March 21, 2018 3:00 PM–4:30 PM Room: 404B

**3:00 PM Abstract No. 332**

**Tumor heterogeneity features as predictors of post-ablation local progression in patients undergoing ablation for adrenal metastases**

D. Daye1, A. Tabari1, M. Caton2, N. Frenk1, F. Fintelmann1, M. Gee3, R. Uppot1; 1Massachusetts...
Purpose: Intra-tumor heterogeneity is associated with tumor aggressiveness in various cancer types. The goal of this study is to evaluate the role of pre-ablation CT-based enhancement heterogeneity measures as predictors of posttreatment local progression in patients with adrenal metastases.

Materials: We retrospectively analyzed pre-ablation contrast-enhanced axial CT images of biopsy-proven adrenal metastases in 21 patients (61% male, mean age 64.1 ± 10.3 years) who underwent ablation. Standard prognostic clinical variables were extracted from the patient medical record. The ablated adrenal lesion was manually segmented on pre-ablation CT images. 14 Haralick texture features were extracted from each lesion, as measures of spatial tumor heterogeneity. Cox proportional hazards regression analysis was used to assess the association between the heterogeneity measures and local progression, with adjustment for size as a common imaging prognostic variable. Backward stepwise feature selection was performed using p>0.05 (Wald test) to select for statistically significant features.

Results: 33%, 14% and 53% of patients underwent radiofrequency ablation, microwave ablation and cryoablation respectively. Technical efficacy was 95%. Mean lesion size was 3 ± 0.84 cm. 76% of patients received systemic chemotherapy following ablation. Mean time to local progression was 29.8 months with no significant difference by ablation modality. Pre-ablation tumor entropy (HR<0.1, p = 0.03), inverse order (HR<0.1, p = 0.04), GLCM mean (HR = 6.1, p = 0.03), GLCM variance (HR<0.1, p = 0.04) and GLCM standard deviation (HR = 10, p = 0.02) exhibited significant independent association with local tumor progression. GLCM mean (HR = 9.1, p = 0.03), entropy (HR<0.1, p = 0.04) and GLCM standard deviation (HR = 10, p = 0.02) maintained significant independent contribution to local progression prediction after adjusting for tumor size.

Conclusions: Pre-ablation CT-based intra-lesion heterogeneity measures are associated with posttreatment local tumor progression and may complement current imaging prognostic variables to improve clinical decision making in patients undergoing ablation of adrenal metastases.

Treatment approach for percutaneous ablation of metastatic adrenal masses

A. Smolock1, T. Gade1, G. Nadolski2, S. Stavropoulos1, M. Soulen7, S. Hunt1; 1University of Pennsylvania, Philadelphia, PA

Purpose: The adrenal gland is a common site of metastasis. Palliative ablation can have a role in tumor debulking for symptomatic management or offer an alternative to adrenalectomy for poor surgical candidates. The position of the adrenal in the retroperitoneum often requires access across the diaphragm or adjacent organs. This report describes our experience with percutaneous image-guided ablation of adrenal masses and approach for tumor access.

Materials: HiQ database was reviewed for cases of adrenal ablation performed August 2002 - August 2017. 19 ablations were performed under CT guidance in 12 patients (7 male, median age 61), of which 11/19 (58%) were right-sided. Cases were reviewed for tumor size, etiology, ablation modality, ablation approach, and complications.

Results: Etiologies were lung cancer (7), hepatocellular carcinoma (3), renal cell carcinoma (1), and neuroendocrine tumor (1). Mean adrenal size was 4.4 ± 2.5 cm. Ten of 19 cases (53%) used cryoablation (CA), 3/19 (16%) microwave ablation (MW) and 6/19 (32%) radiofrequency ablation (RF). Mean number of ablation sessions per lesion was 1.3 ± 0.5. Median number of probes was 3 for CA and 1 for RF and MW. Half of CA procedures were performed with conscious sedation. Only 3 cases allowed a direct approach. Alternative approaches included transpleural alone (11/19; 58%) or combination transpleural and transthoracic/transpleural (5/19; 26%). One CA procedure was aborted due to patient syncope, resulting in incomplete ablation. There was one minor complication of self-limited asymptomatic right pneumothorax.

Conclusions: Percutaneous image-guided adrenal mass ablation is technically feasible with a low rate of complications. The location of the adrenal gland makes direct access often unfeasible; however, alternate approaches can provide safe treatment windows.

3:18 PM  Abstract No. 334

CT-guided adrenal mass cryoablation: a safe, well-visualized, and effective treatment

H. Aoun1, P. Littrup2, S. Abdelhadi3, B. Adam1, M. Prus4, M. Rizk4, B. Nahab5; 1Karmanos Cancer Institute, Detroit, MI; 2Crittenton Hospital, Bloomfield Hills, MI; 3Wayne State University/Dmc, Detroit, MI; 4Beaumont Hospital, Royal Oak, MI; 5Detroit Medical Center, Detroit, MI

Purpose: To assess the technical feasibility, efficacy and complication rates of CT-guided percutaneous cryoablation of adrenal masses.

Materials: 37 CT fluoroscopic-guided percutaneous cryoablative sessions were performed on 37 metastatic tumors, in 31 patients, noting tumor size and type, vessel (>3 mm) proximity, recurrences, complications, and anesthesia-managed hypertension monitoring by arterial catheter. Of the 37 tumors, tumor origin was non–small cell lung (15), renal (15), sarcoma–ASPS (2), small cell lung (3), ovarian cancer (1) and colorectal (1). Complications followed the grading system of the National Institutes of Health, Common Terminology of Complications and Adverse Events (CTCAE). Local tumor recurrence and involution was monitored over time with 1, 3, 6, 12 month and annual scans thereafter.

Results: All patients required only conscious sedation. Average tumor and ablation size was 3.3 cm and 5.3 cm respectively. Local recurrence rate was 8.1% (3/37) for an average followup time of 1.3 years. Although recurrences for tumors > 3 cm (15.8% N = 3/19) were greater than for tumors <3 cm (0% N = 0/18), this was not statistically significant (p>0.05). Proximity of major vasculature (ie: aorta/IVC) did not affect recurrence rates
(p>0.1). The major complication (> grade 3) rate was 8.1% (3/37), with two major complications attributable to the procedure. One death was due to a pulmonary embolism unrelated to the ablation procedure. Transient severe hypertension (>260/120) was noted in 2 cases which was rapidly managed medication without sequelae. No significant intra or postprocedural changes in blood pressure since pretreatment with doxazocin was implemented (N = 8).

Conclusions: CT-guided percutaneous cryoablation is a safe, effective and low morbidity alternative for patients with adrenal tumors. Transient hypertension is related only to residual viable adrenal tissue but can be safely managed.

3:27 PM Abstract No. 335

Machine learning–based radiomics improve post-ablation prognostication in patients with adrenal metastases

D. Daye1, A. Tabari1, M. Caton2, N. Frenk1, F. Fintelmann1, M. Gee1, R. Uppot1; 1Massachusetts General Hospital, Boston, MA; 2Brigham and Women’s Hospital, Boston, MA

Purpose: Radiomics analysis is advantageous for the assessment of aspects of tumor biology not readily discernible to the human eye. The goal of this study is to assess the role of pre-ablation CT radiomics analysis in improving outcome prediction of patients who underwent ablation for adrenal metastases.

Materials: In this IRB-approved retrospective study, we identified 21 patients with pre-ablation contrast-enhanced CT imaging who underwent percutaneous ablation for adrenal metastases. Patient survival was available for up to 108 months. Standard clinical prognostic variables were extracted from the medical record. Adrenal tumors were identified on the pre-ablation axial CT series and manually segmented. A heterogeneity phenotype vector consisting of 30 quantitative radiomics features was extracted from each lesion. Cox regression analysis was used to assess for independent contribution of the extracted features to survival prediction. A linear support vector machine (SVM) machine learning technique was applied to the extracted data and to standard prognostic clinical variables, with 10-fold cross validation to avoid overfitting. ROC analysis and the area under the curve (AUC) were used to assess classification performance.

Results: Mean overall patient survival was 35 months. Pre-ablation tumor entropy (HR>10; p = 0.004), inverse order (HR>10; p = 0.013), energy (HR>10; p = 0.008) and standard deviation (HR<0.1; p = 0.005) exhibited significant independent association with patient survival. 7 Laws texture features contributed independently to survival prediction (p<0.01). The trained SVM model based on standard clinical prognostic variables resulted in an AUC of 0.68. An SVM model that includes radiomics features in addition to clinical variables resulted in improved model performance for survival prediction (AUC 0.93; p = 0.024).

Conclusions: Pre-ablation radiomics improves survival prediction in patients with adrenal metastases who undergo ablation by potentially adding tumor characteristics not currently captured by standard prognostic markers. Machine learning-based predictive models incorporating radiomics may improve prognostication in patients undergoing adrenal tumor ablation.

3:36 PM Abstract No. 336

MR/US fusion-guided ultra-focal gold nanoparticle directed photothermal ablation of prostate gland tumors: results in 9 patients (phase II trial)

P. Shukla1, H. Anastos2, J. Winoker2, M. Carrick2, J. Spiakianos2, C. Knauer3, B. Taouli2, S. Lewis3, J. Schwartz2, A. Rastinehad2; 1Mount Sinai Hospital, The Icahn School of Medicine, New York, NY; 2The Icahn School of Medicine at Mount Sinai, New York, NY; 3Icahn School of Medicine at Mount Sinai, New York, NY; 4Icahn School of Medicine at Mount Sinai Hospital, New York, NY; 5Nanospectra Biosciences, Inc, Houston, TX; 6Icahn School of Medicine at Mount Sinai Department of Urology, New York, NY

Purpose: Gold nanoparticle (GNP) mediated laser ablation have been shown in vitro to be biocompatible and safe for the treatment of focal cancer. Herein, we report the first 9 cases in the world using GNP-directed focal laser ablation of prostate tumors using ultrasound (US) and MR/US fusion technology.

Materials: All patients with elevated PSA and sub-centimeter lesions on MRI underwent MR/US fusion biopsy and pathology proven prostate cancer. Patients underwent ultra-focal laser ablation of the tumors using GNP with MR/US fusion guidance. Following infusion of intravenous GNP on Day 0, trans-perineal laser catheters were placed into the prostate lesions for GNP excitation/tumor ablation under MR/US fusion guidance using an electromagnetic-tracked MR/US fusion device (UroNav). At 48 hours post-ablation, the patient is imaged, followed by re-imaging and MR/US fusion-guided biopsy (FBx) at 3 months. All patient demographics, clinical variables, and complications were recorded.

Results: To date, 9 patients (mean age: 69.4 years; range 59-80 years) have been enrolled in the trial. All patients were diagnosed with Gleason 6/7 prostate cancer using trans-perineal MR/US Fusion biopsy. All patients had a solitary lesion with mean tumor volume 0.73 mL (range, 0.6-1.87 cc). The area ablation appeared to cover the tumor on immediate postprocedure MRI in all 9 patients. No procedure related or short-term complications were observed. At the time of abstract submission, 6 patients had reached the 3-month follow-up period. Mean pretreatment PSA was 7.3 ng/mL (range, 5.5-12.4 ng/mL). Mean post-treatment PSA was 3.9 ng/mL (range, 1.5-6.1 ng/mL). Three of six patients (50%) did not have any cancer detected on follow-up biopsy. Two of the Three patients had micro focus of Gleason 6 and the final patient was downgrade from Gleason 4+3 to 3+4.

Conclusions: Recent trends toward less invasive image-guided therapies have been seen as investigators pursue focal targeted therapies. This report is the first in-man demonstration of MR/US-guided ultra-focal prostate ablation using laser activated gold nanoparticle for the treatment of sub-centimeter prostate cancer.

3:45 PM Abstract No. 337

Radiofrequency ablation of parathyroid adenomas to treat clinically significant hypercalcemia

A. Khandelwal1, A. Kapoor2, R. Khandelwal3, D. Agarwal3, S. Gupta3, S. Baijai4; 1Mount Sinai Hospital, The Medicity, Gurgaon, Haryana; 2Medanta-The Medicity, Gurgaon, Haryana; 3Medanta-The Medicity, New Delhi; 4Medanta-The Medicity, Gurgaon, Haryana

Purpose: Percutaneous radiofrequency ablation (RFA) is a safe, effective, and minimally invasive treatment option for parathyroid adenomas. This technique is associated with decreased risk of complications compared to surgical approaches. A multi-center study evaluating outcomes of this technique was performed.

Materials: Four hundred and seventeen patients (461 adenomas) underwent percutaneous RFA procedures for hypercalcemia. Pre-procedural work-up included complete blood count, chemistry profile, and parathyroid hormone (PTH). Following the procedure, patients were observed for 24 hours for complications.

Results: Four hundred and fifteen adenomas were completely ablated. Complete ablation was achieved in 32 days. The mean ablation time was 50.7 minutes. One complication (nephrectomy) was noted in the first patient. No other complications were recorded. The mean postoperative PTH level was 120 ng/mL. At the last follow-up, all patients had normal PTH levels.

Conclusions: Percutaneous RFA is an effective, minimally invasive treatment option for parathyroid adenomas. This technique is associated with decreased risk of complications compared to surgical approaches. Further studies are needed to evaluate the long-term outcomes of this technique.
Purpose: To evaluate safety and effectiveness of sonography-guided percutaneous radiofrequency ablation of parathyroid adenoma in patients with hyperparathyroidism who were unfit for surgery.

Materials: From 2013 to 2017, eight patients (mean age 58.12 ± 11.05) of hypercalcemia and hyperparathyroidism secondary to solitary parathyroid adenoma were included in the retrospective analysis. All the patients were unfit for surgery due to comorbidities. Four patients had chronic liver disease and markedly deranged liver enzymes were awaiting living donor liver transplantation, two patients were recovering from acute severe necrotizing pancreatitis with multiorgan failure and two patients suffered from chronic kidney disease. Deep sedation (n = 3), intubation (n = 2) and local anesthesia (n = 3) were used. Direct approach to the adenoma (n = 3) and transarterial approach (n = 5) was used. Fixed ablation technique (n = 3) with 17G monopolar electrodes (RITA Starburst, Angio Dynamics Inc. Georgia, USA) and moving shot technique (n = 5) with 17G modified internally cooled electrode (VIVA, STARmed, Gyeonggi-do, Korea) were used. Track ablation was not performed. Technical end point was demonstration of absent color flow within the ablated nodule.

Results: Adenoma in close proximity to recurrent laryngeal nerve (n = 3), common carotid artery (n = 1) and esophagus (n = 1) did not require any modification of ablation procedure. Hydrodissection between the common carotid artery and adenoma to obviate the heat sink effect was performed in one patient. Serum calcium levels normalized within 72 hours of the procedure in all patients and preprocedure mean calcium level of 11.9 ± 1.05 was normal in all patients within a week. There was no major complication associated with the procedure. Only one patient had transient hoarseness of voice in post procedure period which got resolved spontaneously within 3 weeks. The patient with pancreatitis and multiorgan failure died after 15 days while all other seven patients remained normocalcemic on 6 months follow-up.

Conclusions: Radiofrequency ablation of parathyroid adenoma is a safe and effective treatment method for hypercalcemia in patients unfit for surgery.

Molecularly targeted photothermal ablation for precision tumor therapy: initial preclinical results

R. Sheth1, A. Cortes2, N. Muñoz3, R. Avritscher4, E. Cressman5, S. Gupta1; 1MD Anderson Cancer Center, Houston, TX; 2The University of Texas MD Anderson Cancer Center, Houston, TX; 3University of Texas MD Anderson Cancer Center, Houston, TX; 4University of Texas M.D. Anderson Cancer Center, Houston, TX

Purpose: Conventional thermal ablation modalities are limited by their lack of tumoral specificity, resulting in unavoidable thermal injury to adjacent non-malignant tissues. An ideal modality would maximize tumor hyperthermia, thus augmenting tumor-specific immune stimulation, and minimize thermal injury to adjacent tissue, thus preventing systemic tumor stimulation. We have previously shown that indocyanine green (ICG) localizes to hepatocellular carcinoma (HCC) with exceptional target-to-background ratios. The purpose of this study was to evaluate the immunologic ramifications of a novel, ICG-mediated molecularly targeted thermal ablation (MTPA) modality that provides tumor-specific heat generation.

Materials: An orthotopic HCC model was generated by subcapsular implantation of syngeneic McArthur RH-7777 (ATCC) hepatoma cells in male Buffalo rats (n = 20). 96 hours following the intravenous administration of 0.5 mg/kg indocyanine green (ICG), MTPA was performed by illuminating the tumor (or adjacent liver tissue as control) with a 785nm near infrared laser coupled to a clinical fiberoptic catheter. Temperatures were measured with a non-contact infrared camera (FLIR). 72 hours following MPTA, liver and tumor tissue were harvested for immunohistochemical analysis of immune cell markers (CD4, CD8, CD25, CD68, a-SMA, CD163).

Results: There was a significance difference in heat generation during MTPA between normal liver (median 48C [range 40-51C]) and tumor tissue (median 64C [range 60-115C]). Ablative temperatures were able to be maintained in the tumor for as long as 20 minutes. Post-ablation fluorescence imaging demonstrated focal deficits in ICG signal at the sites of ablation, confirming that photoablation resulted in photobleaching of the ICG. Moreover, MTPA increases CD8+ cell infiltration into tumors (15.1% vs 0.9%, P < 0.05) and decreases hepatic stellate cells (14.5% vs 3.1%, P < 0.05) and M2 macrophages (0.5% vs 8.3%, P < 0.05) compared to control.

Conclusions: MTPA results in tumor-specific heat generation and local increased adaptive immune activation. Further studies are required to assess the influence of this technique on systemic immunity.
excellent ablation zones, but in some cases, there were small amounts of thermal damage to the body wall. The purpose of this study was to evaluate a modified RAST treatment strategy in a porcine liver model to determine if thermal body wall injuries could be eliminated while maintaining efficacy of tissue destruction.

**Materials:** Six healthy female pigs underwent RAST (VortxRx, Histosonics Inc., Ann Arbor MI) with a 3 cm spherical treatment. The potential for body wall injury in these subjects was successfully eliminated through a reduction of the time-averaged intensity of therapy delivery. Technical success was defined by complete delivery of the planned treatment volume. Ablations were immediately imaged by contrast-enhanced MRI. Animals were subsequently sacrificed for necropsy and tissue was harvested for tissue processing. The livers were fixed in 10% buffered formalin, processed, sectioned at 5 microns, and stained with H&E before submission to a pathologist for analysis.

**Results:** Technical success was 100% with no major complications. On MRI, mean ablation zone size was 3.0 (trans) x 2.9 (AP) x 3.2 (CC) cm with no surrounding edema and no residual enhancement of the ablation zone. Importantly, there was no evidence of body wall edema or injury in any of the subjects. There was no MR or gross pathologic evidence of damage to adjacent structures. At histopathology, the center of the ablation zone was completely destroyed with no surviving cells. The ablation was surrounded by a zone of near-complete ablation approximately 3-5 mm thick and no significant inflammation.

**Conclusions:** RAST performed with a modified treatment strategy to minimize off-target, prefocus heating created near spherical ablation zones that corresponded closely to the preprocedure prescription without evidence of body wall damage or other off-target effects.

---

**4:12 PM Abstract No. 340**

**Review of complications following thermal ablation of colorectal cancer liver metastases**

I. Kurilova1, E. Kaye2, F. Boas2, H. Yarmohammadi2, M. Gonen2, E. Petre2, N. Kemeny2, S. Solomon2, R. Beets-Tan3, C. Sofocleous2; 1Memorial Sloan Kettering Cancer Center; New York, NY; Amsterdam, NL; 2Memorial Sloan Kettering Cancer Center, New York, NY; 3University of Pennsylvania, Philadelphia, PA

**Purpose:** To identify incidence and risks factors associated with complications of thermal ablation of colorectal cancer liver metastases (CRCLM).

**Materials:** After IRB waiver, we reviewed all data related to thermal ablation (RFA and MWA) used in the management of CRCLM from 2002 to 2017. Minor and major complications were reported according to SIR guidelines and classified as: immediate, early and delayed complications. History of Hepatic Artery Infusion Pump (HAIP) and bevacizumab administration, preexisting biliary dilatation, ablation modality, number and size of ablated lesions, ablation zone volume, minimal ablation margin size and history of hepatectomy were analysed as potential risk factors. Statistical analysis included Kaplan Meier method, logistic regression adjusted for clustering and exact logistic regression. P<0.05 was considered to be significant.

**Results:** 243 patients underwent 296 ablations: 198 (67%) RFA and 98 (33%) MWA. Side effects, minor and major complications were 31 (10%), 34 (11%) and 22 (7%), respectively. Immediate, early and delayed complications occurred after 28 (9%), 12 (4%) and 15(6%) ablations, respectively. There were 14 (5%) biliary, 13 (4%) vascular, 19 (6%) pulmonary and 9 (3%) other complications. There was no 30-day postprocedural death. Median overall survival of the patients with and without major complications was 35 and 41 months, respectively, p = 0.21. All biliary complications patients had prior HAIP and preexisting biliary dilatation. On univariate analysis, biliary complications were associated with prior HAIP (p = 0.0002), preexisting biliary dilatation (p = 0.003), prior bevacizumab (p = 0.012), ablation volume (p = 0.049) and minimal ablation margin (p = 0.024). Multivariate analysis of non-perfect predictors included bevacizumab, ablation zone volume and minimal ablation margin size, which all retained significance. None of the analyzed factors were associated with vascular complications.

**Conclusions:** Thermal ablation of CRCLM has acceptable safety profile. Prior HAIP, preexisting biliary dilatation, bevacizumab administration, ablation zone volume and minimal ablation margin size are associated with biliary complications following thermal ablation of CRCLM.

---

**4:21 PM Abstract No. 341**

**Effectiveness of locoregional therapy for the management of intractable hypoglycemia in metastatic insulinoma**

P. Habibollahi1, M. Soulen1, M. Dagli1; 1Hospital of the University of Pennsylvania, Philadelphia, PA

**Purpose:** To evaluate the duration of response and effectiveness of locoregional therapy (LRT) in treating symptomatic hypoglycemia and achieving local disease control in patients with malignant insulinoma metastatic to liver.

**Materials:** Institutional database was reviewed to identify patients who underwent LRT (Jan 2000-Aug2017) for liver metastases secondary to malignant insulinoma with severe hypoglycemia. Patient characteristics, type of LRT, posttreatment glycemic response and time to recurrence were recorded. Imaging response to LRT was evaluated on posttreatment CT or MRI based on mRECIST criteria.

**Results:** 7 patients (4 male) were identified who had been treated with LRT for insulinoma with hepatic metastases and severe hypoglycemia. The mean age of the patients at the time of first LRT was 60.9 ± 9.2. Mean follow-up period was 3.4 ± 0.9 years. Overall, 21 cycles of LRT were performed (for total of 34 sessions) including 2 cycles of radioembolization (TARE) (total of 3 sessions) and 20 cycles of transcatheter arterial chemoembolization (TACE) (total of 31 sessions). Technical success rate was 97%. One TACE was aborted due to accessory left hepatic artery dissection. Resolution of symptomatic hypoglycemia occurred in 6/7 patients (86%). Mean time to recurrence of intractable hypoglycemia was 629 ± 267 days. Post treatment imaging studies were available after 17 cycles of treatment showing complete response after 1 cycle of TACE, partial response after 8 cycles of TACE and 1 cycle of TARE, stable
Scientific Session 35
Ablation: Science

Wednesday, March 21, 2018
3:00 PM–4:30 PM
Room: 405

Rapid coaxial probe electrochemical (CoPE) ablation device iteration using computer-aided design (CAD) and 3D printing
E. Stein1, N. Perkins1, J. Wildenberg2, S. Hunt2, G. Nadolski2, T. Gade2; 1Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA; 2Interventional Radiology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA

Purpose: Device development has played a central role in the progress of interventional radiology. A primary limitation in device development is the time and cost associated with prototyping using commercially available resources. The advent of rapid, cost-effective 3D printing may facilitate early and effective device development. We hypothesized that CAD and 3D printing would reduce the cost and time associated with prototyping a novel coaxial percutaneous electrochemical (CoPE) ablation device.

Materials: For the 3D-printed device, sketches were created with SolidWorks (Dassault Systemes, France) and prints were prepared in Preform software (Formlabs, MA). A variety of photopolymer resin types, print angles, and support structure densities were trialed using the Form2 printer (Formlabs). An alternative version of the device was constructed by a commercial engineering group and the University of Pennsylvania Research Instrumentation Shop. Both devices were subsequently fitted with nitinol cathodes and a central platinum anode and tested in vitro using 1.5% agarose gel with phenol red indicator after an electric potential was applied.

Results: After three weeks of development time, the CoPE device printed successfully using our 3D printer. At the peak of iteration, new devices were printed daily. With this 3D printing method, average print time was ~6.5 hours and cost was ~$1 per device. The device was able to be updated and printed within the same day, enabling rapid iteration. A fully functional device was generated in three weeks, which could be deployed and retracted. However, in the commercially produced model, the time to prototype was 6 months and cost $8,000 to reach an acceptable product. Unlike our 3D-printed device, it was not fully functional as it could not be retracted. Nevertheless, both devices successfully ablated agarose gel as indicated by acidic and basic color changes.

Conclusions: CAD and 3D printing enabled the successful prototyping of the CoPE ablation device at a reduced cost and with a substantial time savings as compared to commercial production.

Determination of the cryoablation margin: in vivo swine experimentation in renal & hepatic tissue with histopathological assessment: comparison between an abbreviated single 15-minute freeze protocol to the conventional 10-8-10 minute freeze-thaw-freeze protocol
E. Violari1, J. Werner2, R. Liddell2, J. Buethe2, A. Tregnago2, G. Netto2, C. Frangakis2, C. Georgiades2; 1University of Connecticut Health Center, Farmington, CT; 2Johns Hopkins University, Baltimore, MD

Purpose: To determine the frozen but non-lethal margin beyond the periphery of the ablation zone of a single 15 minute freeze protocol and compare it with that of the conventional 10 minute freeze, 8 minute active thaw, 10 minute freeze cycle (10-8-10) in swine liver and kidney. Additionally, the ablation zones were assessed for the presence of islands of viable tissue in both tissues after each protocol.

Materials: Percutaneous CT-guided cryoablation was performed in 5 swine liver and kidney. In each organ, one ablation was performed utilizing the 10-8-10 minute cycle and a second utilizing the single 15 minute cycle. When the “ice-ball” was maximal, 10 cc of black India Ink was arterially infused into the organ. The two ablations were timed to end simultaneously such that the organs were stained at maximal ablation volume. Histologic analysis was performed by pathologist. The ablation length (long axis of the cryoprobe tract) and maximum width (perpendicular to the cryoprobe track) were measured and the tissues were fixed in formalin. 3 μm sections parallel to the cryoprobe track were stained with H&E. Based on the India ink staining pattern, specimens were assessed for non-frozen tissue, ablated tissue, and ablation margin. Finally, the ablated region was examined for islands of viable tissue.

Results: The frozen, but non-lethal margin after cryoablation was found to be approximately 1 mm regardless of the cryoablation protocol performed or the type of tissue. Histopathologic examination of the ablated region showed no cellular viability in any of the tissue specimens, regardless of cryoablation protocol.

Conclusions: An abbreviated, single 15-minute cryoablation resulted in an ablation margin identical to that of the conventional 10-8-10 minute protocol with uniform cell death and no islands of viable tissue remaining in both swine kidney and liver.
### 3:20 PM Abstract No. 344

**In vivo determination of cryoablation size after an abbreviated single 15-minute freeze protocol in swine hepatic and renal tissue in comparison to the conventional 10-8-10 minute freeze-thaw-freeze protocol**

E. Violari¹, J. Werner², R. Liddell², J. Buethe², A. Tregano³, G. Netto⁴, C. Frangakis³, C. Georgiades⁵; ¹University of Connecticut Health Center, Farmington, CT; ²Johns Hopkins University, Baltimore, MD

**Purpose:** To determine the lethal cryoablation size of a single 15-minute freeze protocol and compare it with that of the conventional 10-minute freeze, 8-minute active thaw, 10-minute freeze cycle (10-8-10) in swine liver and kidney.

**Materials:** Percutaneous CT-guided cryoablation was performed in 5 swine livers and kidneys. In each organ, one ablation (2 probes) was performed utilizing the 10-8-10 minute cycle and a second utilizing the single 15-minute cycle. When the “ice-ball” was maximal, 10 cc of India Ink was arterially infused into the organ. The two ablations were timed to end simultaneously so that the unfrozen tissue surrounding both ablation zones was stained at maximal ablation volume. Histologic analysis was performed by a pathologist. The ablation length (long axis of the cryoprobe tract) and maximum width (perpendicular to the cryoprobe track) were measured and the tissues were fixed in formalin.

**Results:** Histopathologically determined ablation length in the 10-8-10 samples was 5.00 ± 0.75 cm and 6.55 ± 0.55 cm for kidney and liver tissue, respectively. For the 15-minute single cycle the respective sizes were 4.96 ± 0.32 cm and 6.85 ± 0.49 cm. Similarly, ablation width in the 10-8-10 samples was 3.95 ± 0.17 cm and 4.5 ± 0.3 cm for kidney and liver, respectively, in the 10-8-10 samples and 4.00 ± 0.44 cm and 4.3 ± 0.28 cm, for kidney and liver, respectively, in the 15-minute samples. Neither ablation length nor width (and consequently volume) were significantly different between the cryoablation protocols. In addition, this was true in both kidney and liver tissue. However, ablation length and width were significantly smaller in the kidney when compared to the liver, for each cryoablation protocol. This observation can be explained by the higher tissue perfusion in the kidney compared to the liver (fourfold), and the role this perfusion plays in heat exchange within the tissue (the heat pump effect).

**Conclusions:** An abbreviated, single 15-minute cryoablation results in an identical ablation size to that of the conventional 10-8-10 minute protocol, regardless of tissue. A larger cryoablation zone observed in hepatic tissue can potentially be explained by differences in tissue perfusion.

### 3:30 PM Abstract No. 345

**Safety and feasibility of immuno-cryotherapy**

J. Raja¹, A. Ghodadra¹, S. Gettinger¹, H. Kluger¹, M. Sznol¹, H. Kim¹; ¹Yale School of Medicine, New Haven, CT

**Purpose:** To investigate the safety and feasibility of image-guided immuno-cryotherapy in patients with immune checkpoint inhibitor failure.

**Materials:** Consecutive patients with primary or acquired failure to immune checkpoint inhibitor therapy were studied following treatment with concomitant image-guided cryotherapy and immune checkpoint inhibition. In addition to demographic features, type of malignancy, size of targeted metastatic lesion, number of cycles of cryotherapy, systemic immunotherapy, and adverse events in a 90 day post procedural window were extracted. The primary end point was safety and adverse events stratified by the common terminology for adverse events (CTCAE) criteria. As a secondary endpoint, efficacy of the cryotherapy was assessed by iRECIST.

**Results:** Ten patients underwent combined image-guided cryotherapy and checkpoint immunotherapy between 2015 and 2017. Five patients received CTLA 4 blockade with cryotherapy, and 8 patients received PD1 axis blockade and cryotherapy. Six patients had metastatic non–small cell lung cancer and 4 had metastatic melanoma. Immunoprofiling demonstrated one patient each with a mutation in NRAS (G12C), NRAS (Q61R), KRAS (G12C), and ALK; and 2 with aBRAF V600E mutation. Cryotherapy was performed in immunotherapy failure sites, including liver (5) and adrenal glands (3), lymph node and muscle. The median size of targeted lesions was 4.5 cm (standard deviation 3.7 cm). There were no grade 3 or higher adverse event, though 6 patients had grade 1 and 2 adverse effects in the periprocedural period which included fatigue, local pain, and poor appetite, isolated cases of diarrhea, colitis, pneumothorax, and procedural site hematoma. Regarding therapeutic response: 5 patients demonstrated partial response, 1 stable response, and 1 progression of disease. Two patients died in the followup period from non-treatment induced causes and 1 is awaiting follow-up. Disease control rate was 85.7%.

**Conclusions:** Immuno-cryotherapy with immune checkpoint therapy in patients with immune checkpoint inhibitor resistance is safe and feasible in metastatic NSCLC and melanoma. There were no grade 3 or above adverse events.

### 3:40 PM Abstract No. 346

**Evaluation of the heat sink effect in combination therapy with embolization and thermal ablation**

C. Puza¹, Q. Wang², C. Kim³; ¹Duke University School of Medicine, Durham, NC; ²Duke Univ/Huazhong University of Science and Technology, Durham, NC; ³Duke University Medical Center, Durham, NC

**Purpose:** Combination of transarterial embolization (TAE) or transarterial chemoembolization (TACE) with thermal ablation results in significantly larger ablation zones, tumoral response rates, and survival. However, the mechanism for this improved efficacy is poorly understood. The purpose of this study was to assess the degree of contribution of the heat sink effect when combining thermal ablation with transarterial embolotherapies.

**Materials:** In vivo experiments were performed in rabbits in this IACUC-approved study. For the control group, rabbits underwent either radiofrequency ablation (RFA) or microwave ablation (MWA) of liver tissue (n = 8 per group). To assess the effect of embolization on heat conduction in normal parenchyma during thermal ablation, rabbits first underwent (TAE) of the hepatic arterial tree followed by either RFA or MWA (embolized group, n = 8 per group). Given that tumors rely nearly completely on the hepatic arterial tree rather than the portal venous system, TAE of a
tumor results in nearly complete loss of blood flow within the tumor. To simulate this complete tumoral nonperfusion in a non-tumor model, rabbits were sacrificed then immediately underwent either RFA or MWA of normal parenchyma (non-perfused group). During ablation, temperatures were obtained from a thermocouple located 1 centimeter away from the probe. For MWA, probe tip temperatures were also measured.

**Results:** In all treated animals, the temperature 1 cm away from the ablation probe was significantly increased after thermal ablation. After embolization, neither RFA nor MWA demonstrated significantly increased heat conduction compared to controls. In the non-perfused group, heat conduction was significantly increased after RFA compared to controls ($p = 0.007$) but not after MWA. However, with MWA, the probe tip temperature was significantly higher in the non-perfused group compared to the control and embolized group.

**Conclusions:** These results suggest that the heat sink effect plays a role in increased heat conduction within nonperfused (embolized) tumor but not normal parenchyma. The effect is more prominent with RFA than MWA.

### 3:50 PM Abstract No. 347

**Ex vivo liver model temperature is a significant factor in ablation zone dimensional reference values claimed by manufacturers**

J. Brannan¹, K. Koly¹; ¹Medtronic, Boulder, CO

<table>
<thead>
<tr>
<th>Model Temperature (°C)</th>
<th>Ablation Time (sec)</th>
<th>N</th>
<th>Mean Ablation Diameter (cm)</th>
<th>St Dev Ablation Diameter (cm)</th>
<th>Mean Ablation Length (cm)</th>
<th>St Dev Ablation Length (cm)</th>
<th>Mean Ablation Volume (ml)</th>
<th>St Dev Ablation Volume (ml)</th>
<th>Mean Ablation Shape</th>
<th>St Dev Ablation Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>60</td>
<td>6</td>
<td>1.77</td>
<td>0.082</td>
<td>2.48</td>
<td>0.184</td>
<td>4.08</td>
<td>0.636</td>
<td>0.71</td>
<td>0.036</td>
</tr>
<tr>
<td>17</td>
<td>210</td>
<td>6</td>
<td>2.90</td>
<td>0.179</td>
<td>2.92</td>
<td>0.407</td>
<td>12.95</td>
<td>2.770</td>
<td>0.90</td>
<td>0.084</td>
</tr>
<tr>
<td>17</td>
<td>510</td>
<td>6</td>
<td>4.02</td>
<td>0.194</td>
<td>4.03</td>
<td>0.250</td>
<td>34.16</td>
<td>4.120</td>
<td>0.95</td>
<td>0.039</td>
</tr>
<tr>
<td>17</td>
<td>600</td>
<td>6</td>
<td>4.23</td>
<td>0.242</td>
<td>4.15</td>
<td>0.351</td>
<td>39.25</td>
<td>7.200</td>
<td>0.96</td>
<td>0.043</td>
</tr>
<tr>
<td>17</td>
<td>900</td>
<td>6</td>
<td>4.82</td>
<td>0.075</td>
<td>4.78</td>
<td>0.232</td>
<td>58.16</td>
<td>4.120</td>
<td>0.97</td>
<td>0.016</td>
</tr>
<tr>
<td>17</td>
<td>1200</td>
<td>6</td>
<td>5.20</td>
<td>0.374</td>
<td>5.05</td>
<td>0.321</td>
<td>71.99</td>
<td>11.990</td>
<td>0.95</td>
<td>0.052</td>
</tr>
<tr>
<td>25</td>
<td>300</td>
<td>6</td>
<td>3.65</td>
<td>0.226</td>
<td>3.68</td>
<td>0.122</td>
<td>25.87</td>
<td>4.630</td>
<td>0.94</td>
<td>0.035</td>
</tr>
<tr>
<td>25</td>
<td>600</td>
<td>6</td>
<td>4.67</td>
<td>0.151</td>
<td>4.50</td>
<td>0.037</td>
<td>51.39</td>
<td>4.040</td>
<td>0.96</td>
<td>0.025</td>
</tr>
<tr>
<td>35</td>
<td>120</td>
<td>6</td>
<td>3.05</td>
<td>0.138</td>
<td>3.13</td>
<td>0.163</td>
<td>15.28</td>
<td>1.481</td>
<td>0.94</td>
<td>0.044</td>
</tr>
<tr>
<td>35</td>
<td>240</td>
<td>6</td>
<td>3.78</td>
<td>0.117</td>
<td>3.68</td>
<td>0.172</td>
<td>27.61</td>
<td>1.913</td>
<td>0.95</td>
<td>0.033</td>
</tr>
<tr>
<td>35</td>
<td>360</td>
<td>6</td>
<td>4.28</td>
<td>0.172</td>
<td>4.15</td>
<td>0.281</td>
<td>40.00</td>
<td>4.960</td>
<td>0.95</td>
<td>0.036</td>
</tr>
<tr>
<td>35</td>
<td>600</td>
<td>6</td>
<td>5.03</td>
<td>0.294</td>
<td>4.75</td>
<td>0.187</td>
<td>63.25</td>
<td>8.540</td>
<td>0.93</td>
<td>0.038</td>
</tr>
</tbody>
</table>

**Purpose:** The purpose of this study is to report how ex vivo model temperature can influence ablation zone dimensional performance claims.

**Materials:** In this study, 72 microwave ablations were created in freshly harvested bovine livers using the Emprint™ ablation system at the 100 Watt generator setting. Bovine livers were submerged in a calibrated temperature controlled water bath prior to ablation testing to enable tight control (±2°C) of model background temperature across three model temperature groups (17°C, 25°C, 35°C). Within the 17°C liver model, ablations were performed for 60, 210, 510, 600, 900 and 1200 seconds. Within the 25°C liver model, ablations were performed for 300 and 600 seconds. Within the 35°C liver model, ablations were performed for 120, 240, 360 and 600 seconds. Immediately upon completion of each ablation sample, the ablation probe was removed and the ablation zone was bisected along the needle path. The ablation zone along the needle shaft (height) and in the cross-needle axis (width) was then grossly measured. Ablation zone cross-sections were photographed and data was statistically analyzed across temperature groupings.

**Results:** Within the 600 second ablation time grouping, the mean ablation width was 4.23 cm (17°C) vs 4.67 cm (25°C) vs 5.03 cm (35°C) ($p<0.001$), the mean ablation height was 4.15 cm (17°C) vs 4.50 cm (25°C) vs 4.75 cm (35°C) ($p = 0.002$), the mean ablation shape metric (minimum dimension/maximum dimension, 1.0 = sphere) was 0.96 (17°C) vs 0.96 (25°C) vs 0.93 (35°C) ($p = 0.278$), and the mean ablation volume (using ellipsoidal calculation) was 39.25 ml (17°C) vs 51.39 ml (25°C) vs 63.25 ml (35°C) ($p<0.001$).

**Conclusions:** Ex-vivo background liver model temperature is a significant factor in microwave ablation dimensional performance. This study demonstrated a 61% increase in ablation volume by increasing model temperature from 17°C to 35°C. Manufacturers of microwave ablation systems utilize different ablation zone dimensional performance. When comparing ablation dimensional performance across microwave ablation systems, the model temperature used by each manufacturer is an important consideration.

### 4:00 PM Abstract No. 348

**Epigenetic alterations enable hepatocellular carcinoma cell survival under metabolic stress**

J. Benjamin¹, M. Silk¹, D. Ackerman¹, S. Hunt¹, G. Nadolski¹, T. Gade¹; ¹University of Pennsylvania,
Penn Image-Guided Interventions Lab, Philadelphia, PA

**Purpose:** Hepatocellular carcinoma (HCC) is the most common primary liver malignancy. Transarterial chemoembolization (TACE) is considered the standard of care for intermediate, non-resectable HCC. Local recurrence is common following TACE. Growing evidence suggests that there are defined, pre-programmed pathways utilized by HCC to survive following metabolic stress induced by TACE including the loss of expression of the tumor suppressor gene fructose-1,6-bisphosphatase (FBP-1). The purpose of this study is to understand the epigenetic changes utilized by HCC cells enabling survival and recurrence following transarterial chemoembolization. We studied the role of hypoxia inducible factor-1α (HIF) and its interactions with FBP-1 in HCC’s response to TACE-like metabolic stress.

**Materials:** HCC cell lines, HUH7 and SNU-449, were grown under normoxic or ischemic conditions in the presence or absence of HIF-1α inhibitor (PX-478) for 48 hours. Cells were then lysed and cell lysates were utilized for western blot analysis, RT-qPCR and immunohistochemistry. We then analyzed the role of FBP1 in regulating the HIF axis by utilizing a FBP1- inducible SNU-449 cell line and collecting cell lysates following FBP1 induction and growth in normoxic versus ischemic conditions. ANOVA analysis was performed to determine statistical significance.

**Results:** There was a significant upregulation of canonical HIF target genes, LDH, GLUT1 and VEGF, following ischemic stress (p-value <0.0001). HIF inhibition using PX-478 abrogated these changes in gene expression. Following FBP1 induction, there was significant repression of LDH expression under ischemia. Interestingly, ischemia induced GLUT1 expression was not repressed following FBP1 induction.

**Conclusions:** The epigenetic loss of FBP1 expression preprograms HCC cells to survive TACE-like ischemia by potentiating the function of HIF. Mitigating this preprogramming may be accomplished by targeting HIF in combination with TACE.

---

**4:10 PM Abstract No. 349**  

Irreversible electroporation is a safe and reproducible technique to induce predictable unilateral ureteral obstruction in a rat model  
L. Vroomen1, M. Fujimori1, A. Sivaraman1, S. Solomon2, G. Srimathveeravalli3; 1Memorial Sloan Kettering Cancer Center, New York, NY; 2Memorial Sloan Kettering, New York, NY; 3Memorial Sloan Kettering Cancer Center, Kew Gardens, NY

**Purpose:** Surgical models of unilateral ureteral obstruction (UUO) are used to study the pathogenesis of chronic renal fibrosis, yet the surgical models induce immediate UUO thereby unable to capture the gradual development of the obstruction and its renal effects. The goal of this study was determine if full thickness IRE can be used for the induction of UUO in a rat model.

**Materials:** Intra-surgical IRE (2000 V/cm, 90 pulses, 100 μs) with caliper electrodes was performed in the right proximal ureter in 24 male rats. Following contrast-enhanced MRI, rats were sacrificed at 2, 5, or 10 days post-IRE. Complete urinary tract (bilateral kidneys, ureter and bladder) was extracted, and scored on a five-point scale for renal dilation, ureteral dilation and hydronephrosis.

**Results:** There were no procedure related complications and all animals survived till designated sacrifice end points. Hallmarks of UUO: dilation of renal pelvis, dilation of ureter superior to site of injury and progressive hydronephrosis was observed at all experimental timepoints, on anatomic scoring on necropsy (at 2 days: 0.7 ± 0.6; 5 days: 1.8 ± 0.9; 10 days: 1.7 ± 1.3) (all p = <0.0001). Increasing severity of UUO was observed between 2 and 5-day follow-up (p = <0.0001), which stabilized hereafter (p = 0.8). Similar findings were observed on MR imaging at equivalent timepoints.

**Conclusions:** Irreversible electroporation is a safe and reproducible technique to obtain a predictable and more representative unilateral ureteral obstruction in a rat model.

---

**4:20 PM Abstract No. 350**  

Interferon-gamma-eluting microspheres for MRI-guided immunotherapy of liver cancer  
W. Park1, A. Gordon2, S. Cho1, X. Huang1, K. Harris1, Z. Zhang2, A. Larson3, D. Kim3; 1Northwestern University, Chicago, IL; 2Northwestern University Feinberg School of Medicine, Chicago, IL; 3Northwestern University/Department of Radiology, Chicago, IL

**Purpose:** The purpose of the study was to develop MRI visible IFN-γ eluting polymeric microspheres a) to avoid systemic toxicities via selective transcatheter infusion and b) permit follow-up imaging confirmation of selective targeting to the liver tumors.

**Materials:** IFN-γ and iron oxide nanoparticles were co-encapsulated in poly(lactide-co-glycolide) microspheres (IFN-γ-MS) via dual emulsion methods. In vitro IFN-γ release studies was performed using ELISA assays. In an orthotopic liver tumor VX2 rabbit model, IFN-γ -MSs were infused via hepatic artery route under X-ray DSA and the delivery of IFN-γ –MS were monitored with R2* scans using a 7T MRI scanner (Clinscan, Bruker, Billerica, MA, USA). To confirm NK cell infiltration into tumors post-IA infusion of IFN-γ-MS, sections of both liver and VX2 tumor tissue were harvested and stained for immunohistochemistry (IHC) analysis. Anti-CD56 IHC slides were analyzed using a TissueFAXS microscope (TissueGnostics GmbH, Austria).

**Results:** Our MR visible drug-eluting polymeric microspheres co-encapsulating IFN-γ and iron-oxide nanoparticles were approximately 10 μm in size. In vitro drug release tests for IFN-γ loaded microspheres exhibited rapid IFN-γ release during initial 24hr time period and then a sustained release over remaining 10 days. Successful hepatic intra-arterial delivery of the IFN-γ MS was confirmed with both MRI and follow-up histology. IFN-γ MS administration clearly elicited potent IFN-γ mediated immunomodulatory effects, with markedly greater natural killer (NK)-cell infiltration observed for treated animals versus matched controls (treated with either transcatheter PBS or unloaded PLGA microspheres).

**Conclusions:** IFN-γ eluting microspheres were developed as an immunotherapeutic approach for the treatment of liver tumors. Our IFN-γ MS system demonstrated image contrast effects for MRI visualization of catheter-directed delivery. Given the promising results of these initial studies, additional investigations are now warranted to rigorously examine longitudinal therapeutic efficacy.
Scientific Session 36
Venous: Thrombus Management

Wednesday, March 21, 2018
3:00 PM–4:30 PM
Room: 406A

3:00 PM
Abstract No. 351

Distinguished Abstract
ACCESS PTS Study: ACCElerated thrombolySiS for post-thrombotic syndrome using the acoustic pulse thrombolysis EkoSonic® endovascular system: midterm results of a multicenter study
M. Garcia1, K. Sterling2, M. Jaff3, K. Ouriel4, I. Weinberg5, S. Kahn6, A. Comerota7; 1Vascular & Interventional Associates of Delaware, Wilmington, DE; 2Inova Alexandria Hospital, McLean, VA; 3Newton-Wellesley Hospital, Newton, MA; 4Syntactx, New York, NY; 5Massachusetts General Hospital, Boston, MA; 6Jewish General Hospital, Montreal, PQ; 7University of Michigan, Ann Arbor, OH

Purpose: Post-thrombotic syndrome (PTS), a potentially devastating long-term outcome of deep vein thrombosis (DVT), develops in >50% of patients following proximal DVT. Unfortunately, treatment options are limited. A multi-center, prospective, single-arm study evaluated the efficacy and safety of endovascular recanalization of venography proven chronic venous-occlusive disease, utilizing venoplasty with ultrasound-accelerated, catheter-directed thrombolysis (USCDT).

Materials: Inclusion criteria were persistent femoral DVT diagnosed ≥6 months, Villalta score (VS) ≥8 and failure of 3 months of anticoagulation and compression therapy. Exclusion criteria were isolated iliofemoral DVT, high bleeding risk as defined by the treating clinician & filling defect ≥3 cm into the IVC. Following standard techniques to cross the venous occlusion, patients underwent venoplasty followed by minimum of 12h USCDT with further venoplasty and venous stenting as needed. Patients will be followed out to 12 months. The primary efficacy endpoint was a reduction in VS ≥ 4 at 30 days post-USCDT in ≥50% of patients. The primary safety endpoints were major bleeding within 72 hours of procedure start and pulmonary embolism (PE) within 30 days post-USCDT. Other measures tracked included the Venous Severity Score (VCSS) and quality of life as assessed by the VEINES-QOL questionnaire.

Results: Of 81 patients enrolled, 78 patients (mean age 55, male 68%) received treatment and 77 limbs were evaluable for endpoint assessment. Mean USCDT duration was 22.8 ± 5.4 hours and tPA dose was 18.5 ± 7.6 mg. The Villalta score improved from 15.8 (baseline) to 9.8 and 8.2 at 30 and 180 days, respectively (p < 0.0001). The actual primary endpoint was met in 67% (p = 0.003). VCSS improved from 12.3 (baseline) to 8.4 and 7.0 at 30 and 180 days, respectively (p < 0.0001). VEINES-QOL improved from 60.6 (baseline) to 70.7 and 80.2 (30 and 180 days, respectively) (p < 0.0001). One major bleed occurred within 72 hours post-USCDT. One PE occurred within 30 days of USCDT.

Conclusions: In chronic DVT patients with PTS, ACCESS PTS demonstrates intervention utilizing USCDT with venoplasty is safe and effective in achieving clinically relevant improvement in PTS and quality of life.

3:09 PM
Abstract No. 352

Endovascular iliocaval stent reconstruction for iliocaval thrombosis: a multi-institutional practice pattern survey
A. Hage1, S. Abramowitz2, R. Srinivasa3, J. Gemmete4, S. Reddy5, M. Khaja1, J. Chick6, 1University of Michigan, Ann Arbor, MI; 2Medstar Washington Hospital Center, Washington, DC; 3N/A, Ann Arbor, MI; 4University of Michigan Hospitals, Northville, MI; 5Main Line Health System, Bala Cynwyd, PA; 6University of Michigan Health System, Ann Arbor, MI

Purpose: To report iliocaval stent reconstruction practices by interventional radiologists.

Materials: A 45-question survey focusing on acute and chronic iliocaval stent reconstruction preprocedural evaluation, intra-procedural practices, and postprocedural care was distributed through the Open Forum and Venous Disease Service Line of the Society of Interventional Radiology Connect website from June 20, 2017, until July 17, 2017.

Results: 102 responses were received from interventional radiologists in the United States and one from South America. 94.2% performed iliocaval reconstruction and 80.4% performed the procedure for both acute and chronic iliocaval thrombosis. 82.5% completed a standardized physician assessment tool and 91.8% obtained computed tomography (CT) venography before the procedure. With regard to intraprocedural practices, 52.6% commonly used two access sites. 63.9% used intravascular ultrasound to guide reconstruction. 41.2% found blunt recanalization successful for >75% of patients. 63.9% used sharp recanalization for <25% of patients. 97.9% and 92.8% used uncovered and self-expanding stents, respectively. Wallstents were used most commonly. Most common stent diameters were 24-mm in the inferior vena cava, 14-mm in the common iliac vein, and 12-mm in the external iliac vein. 49.5% and 20.6% prescribed two and three anticoagulants after stent placement, respectively. 63.9% found iliocaval reconstruction provided symptomatic clinical improvement for iliocaval thrombosis in >75% of patients. 73.2% estimated their 1-year primary stent patency to be >75%. 96.6% believed iliocaval stent reconstruction was worthwhile.

Conclusions: Iliocaval stent reconstruction is performed by many interventionalists; however, there are inconsistencies in practices, suggesting a need for further research and guideline development.
3:18 PM  Abstract No. 353

Nitinol self-expanding stents for the treatment of chronic iliofemoral veno-occlusive disease

C. Chedrawy1, A. Graff8, D. Leung1, D. Agriantoni8, U. Nwosu1, A. Vance3, G. Kimbris1, M. Garcia2, S. Putnam1, K. Lie1, C. Grilli3; 1Christiania Care Health System, Newark, DE; 2Vascular & Interventional Associates of Delaware, Wilmington, DE

Purpose: To evaluate the clinical and technical outcomes of nitinol self-expanding stents for the treatment of symptomatic chronic iliofemoral veno-occlusive disease.

Materials: A retrospective review was performed of 169 consecutive patients (196 limbs) treated with self-expanding nitinol stents for chronic iliofemoral veno-occlusive disease between July 2011 and June 2017. Patients treated with non-nitinol stents and patients with IVC involvement were excluded. Procedural and follow-up data were collected for assessment of technical success, clinical outcomes, safety, and patency. Technical success was defined as the ability to recanalize and stent the obstructive lesion without significant residual stenosis. Binary patency was assessed with duplex ultrasound and calculated by Kaplan Meier analysis. Clinical outcomes were evaluated utilizing CEAP and Villalta scores.

Results: A total of 378 (278 Left, 95 Right) nitinol self-expanding stents were placed with sizes ranging from 8 to 14 mm. Technical success was achieved in 195 of 196 limbs (99%). Of the 169 patients, 100, 45, and 24 presented with symptoms consistent with acute, acute on chronic, and chronic DVT, respectively. Mean followup time was 9.8 months. Kaplan Meier analysis revealed a primary patency of 95%, 93%, 91%, and 91% at 6, 12, 24, and 36 months respectively. Pre- and post-CEAP or Villalta scores were available in 140 (83%) patients. CEAP and Villalta scores improved from 3.65 to 2 (-55%) and 19.15 to 8.6 (-45%), respectively. There were 5 recorded adverse events; 3 mild, 1 moderate, and 1 severe.

Conclusions: Endovascular management of chronic iliofemoral veno-occlusive disease with self-expanding nitinol stents is a safe and durable procedure with high technical success, excellent midterm patency, and good clinical outcomes.

3:27 PM  Abstract No. 354

Update on the Cook VIVO clinical study: a multicenter evaluation of the Zilver vena venous stent in the treatment of symptomatic iliofemoral venous outflow obstruction

L. Hofmann1, A. Comerota2, J. McCann-Brown3; 1University of Michigan, Perrysburg, OH; 2Cook Research Incorporated, West Lafayette, IN

Purpose: The purpose of this prospective, global, single-arm, investigational study is to evaluate the safety and effectiveness of the Zilver Vena Venous Stent in the treatment of patients with symptomatic iliofemoral venous outflow obstruction.

Materials: Symptomatic patients with venous outflow obstruction in a single iliofemoral venous segment underwent treatment with the Zilver Vena Venous Stent (Cook Medical, Limerick, Ireland). The primary study endpoints are: 30-day primary safety endpoint (freedom from major adverse events) and 12-month primary effectiveness endpoint (primary quantitative patency).

Results: 243 patients (70% female; 82% white; mean age of 53 ± 15 years) were enrolled at 30 institutions; study enrollment is complete and patient follow-up is ongoing with data collection out to 36 months. The site-reported indications for stent placement included (note: a single patient may have multiple indications): iliac vein compression by the iliac artery (n = 190; 78%), stenosis due to chronic post-thrombotic obstruction (n = 71; 29%), stenosis after treatment for acute deep vein thrombosis (n = 37; 15%), iatrogenic stenosis (n = 2; 0.8%), extrinsic compression from a mass (n = 2; 0.8%), or other indications (n = 12; 5%). Based on site-reported data, most lesions (n = 209; 86%) affected the vein(s) of the left iliofemoral venous outflow tract. The treated vessel segments included: common iliac vein (n = 216), external iliac vein (n = 148), common femoral vein (n = 66), and femoral vein (n = 7).

Conclusions: Enrollment in the VIVO Study is complete, with clinical and imaging follow-up data collection ongoing. An updated study status will be presented, including final baseline patient and lesion characteristics and procedural outcomes.

3:36 PM  Abstract No. 355

Vein diameters and time to restenosis: an analysis of over 3500 imaging studies

V. Arendt1, D. Cohn1, X. An2, G. Jeon3, L. Hofmann1; 1Stanford University Medical Center, Palo Alto, CA; 2Shanghai General Hospital, Shanghai, China; 3CHA University Bundang Medical Center, Seongnam, Gyeonggi-do, Korea

Purpose: We describe data gathered from an analysis of imaging studies from patients undergoing venous interventions.

Materials: We identified 482 patients (58.7% female; 68.0% white) who underwent venous procedures between 1996 and 2017 and their corresponding 3,554 MR, CT, ultrasound, and conventional venography studies. These studies were analyzed by radiologists using a standardized process to determine vein diameter and vessel patency. Two sample t-tests and Kaplan-Meier curves were used in the analysis.

Results: Of the 19,320 vessels imaged, 73% were widely patent (defined as <5% residual stenosis) and 18% had chronic DVT. Average diameters are shown in the table (p<0.001 for patent vs. chronic DVT in all veins). The only significant difference between corresponding left and right patent vessels is the minimum diameter of the common iliac vein (p<0.001). Of the vessels imaged, 19% contained stents and 20% of stented veins had in-stent restenosis. Restenosis occurred in approximately 27% by 12 months, 32% by 24 months, and 37% by 36 months postprocedure.

Conclusions: Diameters of patent veins and veins with chronic DVT differ significantly. The minimum diameter of patent right and left common iliac veins also differ significantly, likely due to May-Thurner syndrome. After stent placement, our population has a 1/3 restenosis rate that roughly plateaus at 24 months.
techniques and equipment may be effective for sharp recanalization of occluded venous segments. Interventionalists should be aware of the uncommon, but serious complications that have been reported.

3:54 PM  Abstract No. 357

Venous stenting above versus below the inguinal ligament: 20-year experience
D. Cohn1, V. Arendt1, G. Jeon2, X. An3, W. Kuo4, D. Sze5, D. Rubin6, L. Hofmann7, 1Stanford University School of Medicine, Stanford, CA; 2CHA University Bundang Medical Center, Seongnam, GyeongGi-Do; 3Shanghai General Hospital, Shanghai, China; 4Stanford University Medical Center, Stanford, CA; 5Stanford University, Stanford, CA; 6Stanford University, Stanford, CA; 7Stanford University Medical Center, Palo Alto, CA

Purpose: Placement of venous stents across a joint or outside a trunk, such as extending from the pelvis below the inguinal ligament, is suspected of resulting in a higher risk of complications. The goal of this study is to determine if there are differences in restenosis rates in stents in iliac veins versus femoral veins.

Materials: 469 limbs in 377 patients (mean age 46 years, female to male ratio: 1.6:1) treated with venous stents between 1998 and 2017 were retrospectively reviewed. Two cohorts were created: iliac stented veins (common and external iliac veins) versus femoral stented veins (common femoral and femoral veins). Stent location and in-stent restenosis were based on imaging (CT, MR, US, and conventional venography), and evaluated by an interventional radiologist with over 10 years of experience. A stent was classified as having in-stent restenosis if it was not widely patent (<5% restenosis). If a patient had both iliac and femoral vein stents, the patient’s stents were placed, respectively, into both cohorts. Kaplan-Meier estimators were used to assess time until re-stenosis, while the demographic factors of age, gender and ethnicity were considered in the context of the stent restenosis sample.

Results: No statistically significant differences were found between the two stent cohorts in comparing the restenosis Kaplan-Meier curves (log-rank: p = 0.42, median follow-up: 183 days, range: 1 day-13.6 years), ethnicity (Chi-square: p = 0.73), or age (Kruskal-Wallis: p = 0.42). There was, however, a statistically significant difference in the gender-based makeup of the two cohorts (Chi-square: p = 0.003, Fisher’s exact: p = 0.002) (Table 1). The majority of stents that developed restenosis in either cohort did so in the first year of follow-up (Iliac: 1-year cumulative rate: 27.7%, 2-year rate: 32.2%, and 3-year rate: 37.7%; Femoral: 1-year cumulative rate: 36%, 2-year rate: 37.6%, 3-year rate: 37.6%).

Conclusions: The 3-year rates of development of in-stent restenosis in stents placed in iliac and femoral veins were equivalent. Male patients were more likely to require stenting below the inguinal ligament, suggesting that gender may be a possible factor in the anatomical distribution of venous disease.

Table 1. Number of Patients by Vein Stent Cohort and Gender (% of Cohort)

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Female (%)</th>
<th>Male (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iliac</td>
<td>231 (62%)</td>
<td>141 (38%)</td>
</tr>
<tr>
<td>Femoral</td>
<td>62 (47%)</td>
<td>71 (53%)</td>
</tr>
</tbody>
</table>
4:03 PM Abstract No. 358

Anti-thrombotic prophylaxis after iliocaval venous stent placement: which regimen is best?
Y. Jahangiri1, M. Endo1, K. Farsad3; 1Charles T. Dotter Department of Interventional Radiology, Oregon Health & Science University, Portland, OR

Purpose: To identify the effectiveness of antithrombotic prophylactic regimens in prevention of venous stent malfunction.

Materials: Sixty-two patients (median age: 49 years; 59.7% females) who underwent technically successful iliocaval stent placement for May-Thurner syndrome (n = 29), chronic deep vein thrombosis (DVT, n = 30) or malignancy (n = 3) between May 2008 and April 2017 with available follow-up information were retrospectively reviewed. Demographics, post-stenting prophylactic antithrombotic treatments and stent patency at follow-up were evaluated. Stent malfunction was defined as >50% stenosis or occlusion on angiography, duplex US, contrast-enhanced CT or MRI. The association between prophylactic medical regimens and stent malfunction was evaluated by logistic regression analysis.

Results: Median follow-up was 12.1 months (range, 0.6–51.6 months). Stent malfunction occurred in 17 (27.4%) patients after a median of 0.7 months (range, 1 day–7.64 months). Early thrombosis (within 2 weeks post-stenting) occurred in 5 cases. After stenting, 38 patients received antiplatelet treatment with aspirin (n = 26), clopidogrel (n = 8) or both (n = 4), 30 patients received warfarin, 39 patients received enoxaparin and 16 patients received an oral factor Xa inhibitor. Amongst prophylactic treatments, antiplatelet medication use was associated with decreased stent malfunction (OR: 0.22, P = 0.013). Stent malfunction was not observed in patients treated with antiplatelets (n = 2) or factor Xa inhibitors (n = 3) alone, or in patients treated with dual antiplatelet therapy. Stent malfunction occurred in 2 of 3 cases on warfarin alone and 6 of 9 cases on enoxaparin alone (OR: 5.87, P = 0.013). After controlling for patients at risk for DVT, enoxaparin alone remained significantly associated with stent malfunction (OR: 7.95, P = 0.013).

Conclusions: Antiplatelet treatment was the most effective prophylactic regimen to prevent stent malfunction after iliocaval venous stenting. Administration of enoxaparin alone was associated with an increased risk of stent malfunction. Further research will be necessary to understand optimal post-stenting medical management for venous occlusive disease.

4:12 PM Abstract No. 359

Single-session flow restoration in May-Thurner syndrome with secondary acute iliofemoral deep venous thrombosis
V. Young1, R. Lewandowski1, B. Thornburg1, J. Karp1, E. Hohlastos1, R. Gupta1, R. Salem1, K. Desai1; 1Northwestern University, Chicago, IL

Purpose: Catheter-directed thrombolysis (CDT) for iliofemoral deep venous thrombosis (DVT) associated with May-Thurner syndrome (MTS) traditionally requires lytic infusion in an intensive care unit (ICU) and multi-day procedures. The advent of venous-specific thrombolytic devices has improved procedural efficiency. We aim to evaluate the efficacy of single-session therapy utilizing rheolytic pharmacomechanical thrombectomy (PMT) followed by stent placement for MTS with secondary acute DVT.

Materials: MTS patients treated in a single-session were retrospectively analyzed. All procedures were performed utilizing 8Fr rheolytic PMT with power-pulse administration of 10 mg of alteplase into thrombosed segments, 30-minute dwell time, followed by thrombectomy mode. Additional balloon angioplasty/suction thrombectomy was employed as necessary; 14 mm iliac vein self-expanding stents were placed in all patients. Pre- and post-procedure venous clinical severity scores (VCSS) were calculated and paired t-test was performed; significance was determined at p<0.05.

Results: From 7/2016 to present, 6 patients (4M:2F, mean age 51) with acute left iliofemoral DVT secondary to MTS were identified; initial diagnosis was via venous duplex exam. All patients presented with lower extremity edema/pain; mean symptom duration was 3 (range, 1–7) days. Rheolytic PMT with total run time confined to less than 240 seconds, followed by suction thrombectomy (4/6 patients), balloon angioplasty (2/6 patients), and stent placement was performed. Single-session flow restoration with symptomatic relief was achieved in all patients; VCSS decreased from a mean of 6 ± 0.8 (SEM) to 1.8 ± 0.8 (p = 0.002) post-procedure. Patients were followed up by computed tomographic venography (CTV) at approximately 1 month, all patients demonstrated stent patency.

Conclusions: Single-session treatment appears effective for MTS with secondary acute DVT when 8Fr rheolytic PMT is used with local lytic administration, potentially improving DVT thrombolysis safety profile by limiting prolonged lytic exposure and avoiding ICU observation. Further study is necessary to confirm the long-term efficacy of this protocol.

4:21 PM Abstract No. 360

Impact of catheter size, balloon occlusion, and presence of posterior communicating artery during aspiration from internal carotid artery: stroke model of middle cerebral artery (M1 segment) using 3D printing cerebrovascular flow model
M. Horikawa1, T. Nakanishi1, K. Hashimoto2, R. Priest3, K. Farsad3, H. Bozorgchami1; 1Dotter Interventional Institute, Portland, OR; 2Dotter interventional institute, Portland, OR; 3OHSU, Portland, OR; 4Oregon Health and Science University, Portland, OR

Purpose: To clarify the impact of following factors during suction from large-bore catheter at internal carotid artery (ICA) using 3D printing circulation model simulating stroke due to middle cerebral artery (MCA) occlusion. 1. Catheter size, 8F vs. 9F 2. Balloon occlusion (BO) at cervical ICA, (+) vs. (-) 3. Presence of posterior communicating artery (PCOM), (+) vs. (-).

Materials: 3D printing model of cerebrovascular arteries made by silicon was used with perfusion pump maintaining non-pulsatile pressure of 140 mm Hg. The occlusion of the right MCA (M1) was created to simulate acute stroke. Real-time pressure measurement was performed at the origin of right MCA during suction from large-bore catheter at the cervical ICA. Suction was performed using 8-F or 9-F balloon catheter with 60-ml vacuum lock syringe with or without BO. The pressure measurement was performed with and without occlusion of PCOM to simulate a condition of
either presence of PCOM or absence of PCOM. The pressure measurement was performed 10 times for each condition. Repeated measures ANOVA was conducted for statistical evaluation.

**Results:** With the presence of PCOM, pressures (mean/median ± SD) during suction using 8-F with and without balloon-occlusion of ICA are 23.6/23.5 ± 2.72 mm Hg and 32.3/32 ± 2.21 mm Hg. 9-F catheter achieved statistically superior aspiration both with and without BO (-43.6/-50 ± 10.3 mm Hg and -13.2/-9 ± 15.9 mm Hg) to those of 8-F catheter (P<0.000001). Aspiration with BO at ICA was more efficient than without (P<0.000001). There was significant interaction between the catheter size and effect of BO (P = 0.000002). With the absent PCOM, suction using either 8-F or 9-F catheter with and without BO are more efficient than those with the presence of PCOM (8F with BO: -6.7/-5.5 ± 2.36 mm Hg, 8F without BO: 35.0/35.0 ± 1.63 mm Hg, 9F with BO: -49.3/-50 ± 1.50 mm Hg, and 9-F without BO: -33.3/-36 ± 14.2 mm Hg; 8F vs. 9F, P<0.000001; with BO vs. without, P<0.000001).

**Conclusions:** Both larger catheter size and use of BO demonstrated statistically more efficient aspiration with 3D printing stroke model. Significant interaction between catheter size and BO was noted. Presence of PCOM significantly decreased the efficiency of aspiration.

---

**Scientific Session 37**

**Venous Interventions**

*Wednesday, March 21, 2018
3:00 PM–4:30 PM
Room: 406B*

**FEATURED ABSTRACT**

**Abstract No. 361**

**Comparison of bleeding complications between transplenic versus transhepatic access of the portal venous system**

M. Haddad, C. Reisenauer, A. Parvinian, S. Thompson, B. Toskich, J. Andrews, C. Fleming; Mayo Clinic, Rochester, MN; N/A, Rochester, MN; Mayo Clinic, Atlantic Beach, FL

**Purpose:** Determine whether bleeding related complications are more common with transplenic or transhepatic access for portal venous system interventions.

**Materials:** Retrospective review of patients that underwent transplenic or transhepatic access for portal venous system interventions between January 2000 and August 2017. Only patients with both clinical and laboratory follow-up were included. Clinical and treatment outcomes and bleeding related complications were analyzed.

**Results:** One hundred and forty-eight cases were identified. 23 transplenic procedures were performed in 114 patients. Average patient age was 55 years (range, 22-80). Average follow-up was 2.3 years (range, 0.1-14.2). No significant difference between the preprocedural INR (p = 0.136) and platelets (p = 0.234) between the two cohorts. Technical success was achieved in 21 of the 23 (91.3%) transplenic cases and 120 of the 125 (96.0%) transhepatic cases. No significant difference in bleeding related complications between the two groups (p = 0.438), as there were 3 (13.0%) in the transplenic group and 10 (8.0%) in the transhepatic group. No significant difference was also found in terms of major (Clavien-Dindo >III) bleeding complications (p = 0.789) as there was 1 (4.3%) in the transplenic group and 4 (3.2%) in the transhepatic group. No significant difference in the average pre- and post-procedural hemoglobin (g/dl) change was seen (p = 0.418) which in the transplenic group was -1.2 ± 1.0(-3.4-1.0) and -1.0 ± 1.1 (-4.5-1.9) in the transhepatic group. Finally, no significant difference in cases that required post procedural blood transfusion (p = 0.520) as there were 2 (8.7%) in the transplenic group requiring an average of 4 units (range, 2-6) and 17 (13.6%) in the transhepatic group requiring an average of 3.5 units (range, 1-26).

**Conclusions:** Retrospective analysis revealed no significant difference in bleeding related complications between transplenic and transhepatic access for portal venous system interventions. When choosing between transplenic or transhepatic access for the portal system, risk of a bleeding complication should not be a primary deciding factor or deterrent.

**3:09 PM Abstract No. 362**

**Percutaneous transhepatic catheter-directed thrombolysis for the treatment of acute portal and mesenteric vein thrombosis**

H. Chengazi, J. Reis, J. Lin, M. Dokus, M. Balenciuk, R. Kashyap, A. Sharma, D. Butani, V. Khanna, T. Sasson, D. Lee, N. Saad, D. Waldman, J. Xue; University of Rochester Medical Center, Rochester, NY

**Purpose:** To evaluate our institutional outcomes following catheter-directed thrombolysis (CDT) for the treatment of acute portal and mesenteric vein thrombosis (PVT).

**Materials:** A retrospective chart review of all patients with PVT treated with CDT over a ten-year period was performed. Thrombus was quantified using the Yerdel Classification pre- and post-thrombolysis. Demographics, risk factors for PVT, symptoms, clinical and technical success rates, and complications were analyzed. Subgroup analyses were performed comparing cirrhotic and non-cirrhotic patients.

**Results:** Twenty-eight patients (mean age 50.6 years) were treated with CDT over a ten-year period was performed. Average patient age was 55 years (range, 22-80). Average follow-up was 2.3 years (range, 0.1-14.2). No significant difference between the preprocedural INR (p = 0.136) and platelets (p = 0.234) between the two cohorts. Technical success was achieved in 21 of the 23 (91.3%) transplenic cases and 120 of the 125 (96.0%) transhepatic cases. No significant difference in bleeding related complications between the two groups (p = 0.438), as there were 3 (13.0%) in the transplenic group and 10 (8.0%) in the transhepatic group. No significant difference was also found in terms of major (Clavien-Dindo >III) bleeding complications (p = 0.789) as there was 1 (4.3%) in the transplenic group and 4 (3.2%) in the transhepatic group. No significant difference in the average pre- and post-procedural hemoglobin (g/dl) change was seen (p = 0.418) which in the transplenic group was -1.2 ± 1.0(-3.4-1.0) and -1.0 ± 1.1 (-4.5-1.9) in the transhepatic group. Finally, no significant difference in cases that required post procedural blood transfusion (p = 0.520) as there were 2 (8.7%) in the transplenic group requiring an average of 4 units (range, 2-6) and 17 (13.6%) in the transhepatic group requiring an average of 3.5 units (range, 1-26).

**Conclusions:** Retrospective analysis revealed no significant difference in bleeding related complications between transplenic and transhepatic access for portal venous system interventions. When choosing between transplenic or transhepatic access for the portal system, risk of a bleeding complication should not be a primary deciding factor or deterrent.
Do liver function scoring systems predict outcomes after portal vein embolization in non-hepaticellular carcinoma liver cancer?

A. Som, C. Noda, R. Ramaswamy, O. Akinwande; 
Washington University in St. Louis, St. Louis, MO; Washington University School of Medicine, St. Louis, MO; Mallinckrodt Institute of Radiology, St. Louis, MO; Mallinckrodt Institute of Radiology Washington University in St. Louis, St. Louis, MO; Washington University School of Medicine in St. Louis, St. Louis, MO

Purpose: To evaluate whether new pretreatment liver function scoring systems (platelet-albumin-bilirubin (PALBI) and albumin-bilirubin (ALBI)) predict outcomes after portal vein embolization (PVE).

Materials: 151 consecutive patients between 1/1/2001 and 8/1/2016 were analyzed. Only non-hepaticellular carcinoma liver cancer was included. ALBI, PALBI, CP scores were correlated with post-PVE-hepatectomy survival using Kaplan Meier and Cox Regression statistics. Spearman rho correlation was used to evaluate correlations between liver volume and function. Chi squared tests were used to evaluate relationship to adverse events.

Results: Overall, patients undergoing PVE had a median overall survival (OS) of 994 days, an average 186.1 cc increase in functional liver remnant. The majority of patients were Child-Pugh (CP) A (93%). PALBI separated all patients into three grades (1(68%), 2(30%), 3(1%), p = 0.0395). ALBI also discriminated, but was not as good as PALBI (grade 1(64%), 2(20%), 3(16%), p = 0.422). Median OS for ALBI grade 1, 2 patients were 35.3 months, respectively (p = 0.3031). ALBI grade-3 sample was too small for OS calculation. Median OS for ALBI grade 1, 2 and 3 patients were 34.7 months, 34.03 m, and 13.9 m, respectively (p = 0.0395). PALBI correlated with post total estimated liver volume (TELV) (p = 0.0413) and completed hepatectomy, while ALBI did not. PALBI showed negative correlation with post-PVE% functional liver remnant (p = 0.0094). None of the scores, Child-Pugh, PALBI or ALBI correlated with adverse events.

Conclusions: Despite a non-cirrhotic population, PALBI and ALBI can stratify PVE patients more effectively than CP status. Only PALBI correlates with post-PVE surgery, survival after PVE-hepatectomy, TELV, and post PVE% functional liver remnant.

Recanalization of chronic visceral venous occlusions

S. Flanagan, A. Feng, S. Young, D. Hunter; 
1University of Minnesota Medical Center, Minneapolis, MN; 2University of Minnesota, Minneapolis, MN; 3University of Minnesota, Edina, MN

Purpose: Occlusion of the portal, superior mesenteric or splenic vein can be seen in patients with a variety of conditions including cirrhosis, pancreatitis, liver transplant, and hypercoagulable states. Occlusions are associated with significant morbidity and mortality, most severe being upper gastrointestinal bleeding, and can also be a contraindication to abdominal surgery. The aim of this study is to describe one academic institution’s approach to visceral venous recanalization in patients with chronic, long segment total occlusions.

Materials: We retrospectively reviewed recanalizations performed in 17 patients utilizing a percutaneous transhepatic or transplenic, surgically assisted mini-laparotomy, or combined approach depending on location and extent of occlusion. Duration of occlusion ranged from 2 months to 17.3 years (mean 2.7 years). Patients with portal hypertension related to liver disease underwent TIPS to achieve adequate flow across the recanalized segments. Periodic clinical and imaging follow-up was performed.

Results: 26 vessels in 17 patients (age 2-69 years, mean 35.3 years) were successfully recanalized. 11 portal, 9 superior mesenteric, and 6 splenic veins were recanalized. Mean length of occlusion was 5.03 cm (range, 1.4-13.5 cm). 13 stents were placed in recanalized veins with residual, flow limiting stenosis following angioplasty. TIPS was placed in 3 patients. Median follow-up was 15 months. Primary patency was maintained in all patients but one, in which patency was lost due to subtherapeutic outpatient anti-coagulation. There were no procedure related mortalities. Indications included variceal bleeding (n = 11), preoperative (n = 3) in order to decompress varices for abdominal surgery, early mesenteric ischemia (n = 2), and recurrent ascites (n = 1). All patients had resolution of symptoms. 3/3 preoperative recanalizations underwent successful abdominal surgery.

Conclusions: Visceral venous recanalization is technically achievable in long-term occlusion and should be considered for patients with complete occlusions that have caused clinical problems. An exciting newer indication we highlight is preoperative recanalization to decompress varices and thus allow for abdominal surgery.
3:36 PM Abstract No. 365

Bifurcated Y-stent placement for treatment of superior vena cava syndrome involving both brachiocephalic veins and superior vena cava

J. Tseng1, D. Wang2, J. Louie3, D. Sze2; 1Stanford University, Stanford, CA; 2Stanford University School of Medicine, Stanford, CA

Purpose: To review outcomes after in situ bifurcation Y-stenting for treatment of complex superior vena cava (SVC) syndrome patients with obstruction involving SVC and both brachiocephalic veins (BCV).

Materials: From January 2001 to August 2017, 18 patients (mean age 54 y; 9 male) with SVC syndrome were treated with the Y-stent technique. All patients had occlusions and/or stenoses of both BCVs and SVC due to malignancy (n = 10), central venous catheterizations (n = 7), or mixed etiologies (n = 1). After recanalization of the obstructive lesions, Y-shaped stents were constructed in situ by placement of a 12 or 14 mm nitinol stent from one BCV to the SVC, selective balloon fenestration of the stent istertices into the other BCV, placement of a contralateral BCV-SVC stent through the fenestration, and symmetrical fenestration of the second stent to minimize exclusion (jailing) of branches. Technical success, clinical success, peri-procedural complications, and long-term outcomes were retrospectively evaluated.

Results: All 18 Y-stent deployments were technically successful, resulting in resolution of SVC syndrome symptoms in 100%. Peri-procedural complications included one patient with transient stress-induced cardiomyopathy, but no venous injuries or procedure-related deaths. Of the 12 patients with >30 d follow-up (median 6.4 mo, range 1.1-87.6 mo), 10 (83.3%) had no recurrence of symptoms. Among 7 patients with >30 d contrast-enhanced CTs (median 9.2 mo, range 1.1-70.0 mo), all stents were patent in 5 (71.4%). Two patients, both on chronic hemodialysis with arm arteriovenous fistulas, developed symptom recurrence and in-stent stenoses, requiring secondary interventions.

Conclusions: Bifurcation Y-stent placement is a feasible and effective technique for treatment of problematic SVC syndrome caused by obstructive lesions involving bilateral BCVs and SVC. Y-stenting can maintain patency of all branches, and durability appears to be similar to that of simpler anatomy involving only single vessels.

3:54 PM Abstract No. 367

Varicocele embolization with endovascular coils versus coils and sclerotherapy: an analysis of technical and clinical outcomes from a large retrospective series of over 1000 patients

E. Tarulli1, A. Jaberi2, H. Jaffer1, J. Kachura3, G. Annamalai4, E. Zhang5, J. Beecroft6; 1University of Toronto, Toronto, ON; 2University of Toronto, University Health Network, Toronto, ON; 3Toronto General Hospital, Toronto, ON; 4Mount Sinai Hospital and University Health Network, Toronto, ON; 5Sunnybrook Health Sciences Centre, Toronto, Ontario; 6N/A, Toronto, ON

Purpose: Varicocele embolization is a minimally invasive procedure developed to treat varicoceles without surgical intervention. Techniques for varicocele embolization vary with some centers touting the use of embolization coils alone, sclerosant materials, embolic materials or combinations thereof. Few studies have compared embolization strategies to determine whether using coils alone or the addition of sclerosing agents results in better technical success, fewer complications, shorter procedure time, patient radiation, cost or improved fertility parameters. This study consists of the largest cohort study population reported to date comparing coils versus coils and sclerosant.

Materials: This is a retrospective, single-center chart review including patients receiving standard of care treatment for varicocele embolization for infertility or symptoms performed between July 1, 2000 and August 30, 2017 divided into two cohorts: coil and July 2017. Only cases with both clinical and imaging follow-up were included. Clinical and treatment outcomes and the percent stenosis of each stent were evaluated.

Results: Fifty-eight patients were identified. 37 (64%) cases were due to a chronic line/pacemaker and 21 (36%) were due to fibrosis mediastinitis. 36 (62%) were placed on anticoagulation post stenting and 22 (38%) were not placed on anticoagulation post stenting. Technical success was achieved in all cases. There was no significant difference (p = 0.340) in the number of patients who reported a return of symptoms between the anticoagulated (16/36 or 44.4%) and non-anticoagulated (11/22 or 50%) groups. There was also no significant difference (p = 0.361) in the mean percent stenosis between the anticoagulated (40.4% (range, 0-100) ± 34.7) and non-anticoagulated (32.1% (range, 1.7-100) ± 29.2) groups. No significant difference (p = 0.488) was found in the time (days) between the date of procedure and date of return of symptoms (anticoagulated: 735.9 (range, 23-3851) ± 1003.1 and non-anticoagulated: 478 (range, 28-2922) ± 826.6). There was furthermore no difference (p = 0.591) in the primary patency between both groups. Finally, 2 (5.6%) patients in the anticoagulated group went on to require surgical intervention while none in the non-anticoagulated group went on to surgical intervention.

Conclusions: No significant difference occurred in clinical and treatment outcomes in patients who were and were not anticoagulated after stenting for benign SVC syndrome. Thus in especially young patients with no comorbidities requiring anticoagulation, post stent management of benign SVC syndrome may not require anticoagulation.

3:45 PM Abstract No. 366

Is anticoagulation required after stenting for benign superior vena cava (SVC) syndrome?

M. Haddad1, M. Neisen2, I. McPhail3, M. Kalra1, A. Stockland2, E. Bendel1, J. Andrews2, N. Neidert2, S. Misra1, H. Bjarnason1; 1Mayo Clinic, Rochester, MN; 2University of Rochester, Rochester, MN; 3St Marys Hospital, Rochester, MN

Purpose: To identify whether symptom relief and stent patency vary with the use of anticoagulation after stenting for benign SVC syndrome.

Materials: We retrospectively identified all patients with benign SVC syndrome treated with stent placement between January 1999 and July 2017. Only cases with both clinical and imaging follow-up were included. Clinical and treatment outcomes and the percent stenosis of each stent were evaluated.

Results: Fifty-eight patients were identified. 37 (64%) cases were due to a chronic line/pacemaker and 21 (36%) were due to fibrosis mediastinitis. 36 (62%) were placed on anticoagulation post stenting and 22 (38%) were not placed on anticoagulation post stenting. Technical success was achieved in all cases. There was no significant difference (p = 0.340) in the number of patients who reported a return of symptoms between the anticoagulated (16/36 or 44.4%) and non-anticoagulated (11/22 or 50%) groups. There was also no significant difference (p = 0.361) in the mean percent stenosis between the anticoagulated (40.4% (range, 0-100) ± 34.7) and non-anticoagulated (32.1% (range, 1.7-100) ± 29.2) groups. No significant difference (p = 0.488) was found in the time (days) between the date of procedure and date of return of symptoms (anticoagulated: 735.9 (range, 23-3851) ± 1003.1 and non-anticoagulated: 478 (range, 28-2922) ± 826.6). There was furthermore no difference (p = 0.591) in the primary patency between both groups. Finally, 2 (5.6%) patients in the anticoagulated group went on to require surgical intervention while none in the non-anticoagulated group went on to surgical intervention.

Conclusions: No significant difference occurred in clinical and treatment outcomes in patients who were and were not anticoagulated after stenting for benign SVC syndrome. Thus in especially young patients with no comorbidities requiring anticoagulation, post stent management of benign SVC syndrome may not require anticoagulation.
Nutcracker syndrome as a cause of recurrent symptoms in pelvic congestion syndrome patients who underwent gonadal vein embolization

N. Viradia1, D. Middleton1, W. Pabon-Ramos2, D. Sopko2, M. Miller2, C. Kim1; 1Duke University Medical Center, Durham, NC; 2Emory University School of Medicine, Atlanta, GA

Purpose: Left renal vein compression by the SMA (nutcracker syndrome) prevents normal flow from the left renal vein into IVC and can divert flow into the left ovarian vein in women, resulting in pelvic congestion syndrome symptoms. In these patients, embolization of the left ovarian vein result in renal venous hypertension, which may predispose patients to new or recurrent symptoms. The purpose of this study was to investigate the clinical implications of left renal vein compression in patients who underwent left ovarian vein embolization.

Materials: In this retrospective study, 79 patients underwent left ovarian vein embolization. Of these, 40 females (mean age 44.5 years) had a contrast-enhanced CT or MRI prior to the procedure and adequate clinical follow-up. Electronic medical records were reviewed to capture clinical symptomology before and after embolization. On preprocedural CT or MRI, the percent compression of the left renal vein (LRV) by the SMA was measured, as was the diameter of the left lumbar vein at the level of the LRV. Categorical variables were compared with the chi square test.

Results: Left ovarian vein embolization was performed due to pelvic pain in 33 patients. In 7 patients, embolization was performed due to leg pain, swelling, or varicosities without pelvic pain. Of the patients with pelvic pain, 75% had improvement in symptoms. Overall, 27 patients reported recurrent, new, or unimproved pelvic pain or flank pain at a median of 159 days. In patients with 60% or greater narrowing of the LRV at the level of the SMA, 80% had recurrent/new/unchanged symptoms compared to 28% in patients without LRV compression (p = 0.003). The presence of a prominent left lumbar vein was significantly associated with LRV compression (p<0.001). The presence of both LRV compression and a prominent left lumbar vein had a 100% positive predictive value for recurrent/new/unimproved symptoms.

Conclusions: The presence of nutcracker syndrome correlated significantly with recurrent or new symptoms after left ovarian vein embolization. Assessing its presence prior to embolization may be important to optimize outcomes; an alternative therapy may be warranted.
**Purpose:** To investigate the safety, efficacy, and outcomes of transfemoral transcapillary (TFTC) core-needle liver biopsies.

**Materials:** We previously published our results of the first 66 patients using TFTC as an alternative to transjugular liver biopsy, where hepatic tissue is directly obtained through the infraportal inferior vena cava via a femoral venous approach. In this retrospective study, the medical, surgical, and radiological records of patients who underwent transvenous liver biopsies at a single institution between February 2014 and August 2017 were performed. This is a follow-up study where we present the outcomes and complications of over 200 patients. Procedural complications were classified according to the Society of Interventional Radiology guidelines.

**Results:** 204 total TFTC liver biopsies (61.5% male; mean age 51.1 ± 15.5 years) accounted for 75.0% (204/272) of the transvenous liver biopsies. Technical success was achieved in 98.5% (201/204) of cases. Histopathologic diagnoses were made in 198 cases (97.1%). Fragmented or limited samples in which a pathologic diagnosis was still made occurred in 6 cases (3.0%). Complications occurred in 4 cases (1.9%). There was one case with delayed bleeding at the femoral puncture site requiring a small subhepatic hematoma, not requiring any transfusion and a figure eight stitch. Venous pressure measurements were requested in 171 cases and were successfully obtained in all.

**Conclusions:** TFTC core-needle liver biopsy is a safe and highly effective method of obtaining hepatic tissue samples and venous pressure measurements.

---

**Purpose:** Circulating epithelial cells (CECs) have been isolated from a variety of cancers that can serve as a liquid biopsy. Here, we evaluated CECs in a cohort of hepatocellular carcinoma (HCC) patients with quantitative tumor volume analysis to determine if there was a relationship of tumor size to CEC generation. Our goal was to see whether CEC detection could be used to diagnose, assess for treatment response and recurrence following percutaneous treatment of HCC.

**Materials:** CTC-iChip for HCC CEC isolation and detection was optimized using the HepG2 cell line and then tested in 22 HCC patients. 10 cc of blood from each patient was analyzed with the iChip using an established protocol; HCC cells from the iChip product were confirmed using immunostaining with antibodies to cytokeratin and glypican-3. Tumor volumetric studies were performed using standard software and clinical demographics were obtained from the EMR.

**Results:** In 24 tumor volumetric analyses, a cutoff of 25 cc was used to create a low and high tumor volume group (median 5.56 vs 108 cc; p<0.0001). Using the CTC-iChip and immunofluorescent staining for cytokeratin and glypican-3, CECs were detected in 18 of 22 (82%) HCC patients. CECs/mL of blood did not correlate with either tumor volume or serum AFP. Interestingly, CECs were found to be significantly higher in small compared to large volume tumors (median 18.5 vs 5 CECs/mL; p = 0.0454). Altogether, HCC CECs provide additional data about the tumor independent of imaging and blood biomarkers, and there may be biological differences in early small volume tumors that facilitate CEC entry into the blood stream.

**Conclusions:** Detection of HCC circulating tumor cells has implications as a biomarker for predicting treatment response, recurrence and a potential for early diagnostic platform.

---

**Isolation of circulating hepatocellular carcinoma cells in patients using the iChip: hydrodynamic cell sorting, inertial focusing, and magnetophoresis**

R. Oklu1, H. Albadawi1, R. Sheth2, D. Ting2; 1Mayo Clinic Arizona, Phoenix, AZ; 2MD Anderson Cancer Center, Houston, TX; 3Massachusetts General Hospital, Harvard Medical School, Boston, MA

**Purpose:** In vitro evaluation of irinotecan loaded biodesorbable microspheres for arterial chemoembolization

T. Pan1, L. Weng1, R. Donelson1, J. Golzarian1; 1University of Minnesota, Minneapolis, MN

**Materials:** BRMS were prepared from carboxymethyl cellulose and chitosan by using an inverse emulsion method. The degradability of these microspheres in 10 μg/mL lysozyme at 37°C was determined by gravimetry. Drug loading was performed by immersing 100-300 μm BRMS in an irinotecan hydrochloride solution (20 mg/mL) for 2 h. Drug loading efficiency was determined by measuring the irinotecan concentration remaining in the loading solution with a spectrophotometer at 369 nm. The drug distribution inside the microspheres was determined with multiphoton confocal fluorescence microscopy. Release experiments were performed in distilled water (DI), saline (0.9% NaCl, pH = 5.6) and 0.01 M phosphate buffered saline (PBS, pH = 7.4 and pH = 5.5) under static medium conditions. The suspendability of the drug loaded BRMS was tested in water/contrast agent mixtures in different ratios, and then the injectability was tested with microcatheters (ID = 0.021” and 0.027”).
**Results:** The dry weight of the BRMS showed a consistent decrease over the period of incubation in a 10 μg/mL lysozyme solution with 39.1% mass remaining on day 21. Irinotecan was loaded efficiently onto the 100-300 μm BRMS with a loading percentage of 90.67% and an average of 14% decrease in the microsphere size at 2 h. Confocal imaging revealed an even distribution of irinotecan throughout the BRMS. In different releasing media, drug loaded BRMS released irinotecan at different rates depending on the ion concentration. At 2 h, the percentage of drug released were 12.7 ± 3.0%, 98.1 ± 2.7%, 99.4 ± 1.0%, and 100.0 ± 0.0% for 100-300 μm BRMS in DI, saline, PBS (pH = 7.4) and PBS (pH = 5.5), respectively. Drug loaded BRMS formed a stable suspension in a 7:3 water/contrast mixture, which could be easily injected through microcatheters without aggregating or clogging.

**Conclusions:** BRMS are promising as carriers for irinotecan delivery in arterial chemoembolization.

---

**3:18 PM Abstract No. 373**

**Quiescent hepatic stellate cell condition media induces caspase-independent apoptotic cell death and potentiates effects of doxorubicin in hepatocellular carcinoma cell lines**

A. Wadera1, D. Das2, E. Fayazzadeh3, G. McLennan4; 1New York Medical College, Valhalla, NY; 2Cleveland Clinic Foundation, Cleveland, OH; 3Cleveland Clinic, Cleveland, OH; 4Cleveland Clinic, Chagrin Falls, OH

**Purpose:** Quiescent hepatic stellate cells (Q-HSC) and their subsequent state of activation have an important role to play in the progression of hepatocellular carcinoma (HCC). The purpose of the project was to characterize the mode of cell death induced by quiescent hepatic stellate cells condition media (LX2-CM) on HCC cell lines derived from rat and humans. This research will provide a better understanding of anti-tumorigenic properties of Q-HSC and help develop potential therapeutic targets.

**Materials:** Two patient-derived primary HCC cell lines—HCC11 and HCC37—and N1S1 rat-derived HCC cell line were used. Cells were exposed to treatment conditions (LX2CM, Dox (10μM/ml), ZVAD (20μM/ml), ZVAD + LX2CM, Dox + LX2CM) for 18 hours. Cellular viability was determined with an MTS tetrazolium colorimetric assay after treatment. Reactive Oxygen Species (ROS) assay was done using 2',7'-dichlorofluorescein diacetate (DCFDA) cellular ROS detection assay kit. Western blots for Apoptosis Inducing Factor (AIF) were developed using LI-COR near-infrared fluorescence detection. Green fluorescein conjugated secondary antibody to AIF was used to identify nuclear localization following exposure to LX2-CM.

**Results:** Condition media extracted from Q-HSC (LX2-CM) was cytotoxic to HCC cells. A 23% decrease in cellular viability (p<0.05) was noted in the N1S1 rat HCC cell line compared to control. A 12% decrease in cellular viability (p<0.05) was noted in both human primary HCC cell lines. A synergistic effect with LX2-CM and doxorubicin was also observed in HCC37 and HCC11 cells with a 29.7% and 61.5% (p<0.05) decrease in cellular viability, respectively. Caspase inhibitor (ZVAD) did not reverse cytotoxic effects establishing caspase-independent cytotoxicity. LX2-CM protected HCC cells from ROS as observed from DCFDA detection assay. Western Blots demonstrated increased AIF expression in N1S1 cells exposed to LX2-CM. Immunohistochemistry after LX2-CM exposure demonstrated nuclear localization of AIF indicating a pathway of programmed cell death.

**Conclusions:** Condition media extracted from Q-HSC is cytotoxic to HCC cells. Cell death pathway was determined to be caspase-independent involving nuclear localization of AIF.

---

**3:27 PM Abstract No. 374**

**Investigating the role of HSF1 in ablation: combined stresses block protective responses in multiple human hepatocellular carcinoma cell lines**

C. Guo1, N. Munoz2, U. Polak3, M. Gustin4, N. Karbasian2, E. Cressman5; 1UTMD Anderson Cancer Center, Houston, TX; 2University of Texas MD Anderson Cancer Center, Houston, TX; 3The University of Texas MD Anderson Cancer Center, Houston, TX; 4Rice University, Houston, TX, 5University of Texas M.D. Anderson Cancer Center, Houston, TX

**Purpose:** Survival of tumor cells after thermal ablation contributes to local and systemic disease progression. Thermochemical ablation (TCA) may address this by increasing efficacy and duration of applied stress. Previously, we showed that adding osmotic stress to concurrent heat shock (HS) as occurs in TCA significantly reduces viability of HepG2 and Hep3B cells. However, the mechanism by which osmotic stress augmented cell death induced by heat shock is still unclear. The aim of the present study is to test the hypothesis that osmotic stress reduces cell survival after concurrent heat shock by regulating HSF1, a master regulator of stress response.

**Materials:** Four human hepatocellular carcinoma cell lines, HepG2, Hep3B, SNU398, and SNU449, (obtained from ATCC) were studied. HS was 43°C for 3 hours. 200 mM (400 mOsm) sodium acetate was added for 24 hours for osmotic stress. All 4 lines were subjected to HS ± osmotic stress. Total protein lysates were prepared and protein levels of HSF1, HSP70, HSP60, HSP90, and HSP27 were examined by Western blots. Alamar blue assay was employed to evaluate cell viability.

**Results:** Both total and phosphorylated (S326) protein levels of HSF1 were lower in all 4 cell lines treated with combined stress compared to those treated with HS alone. Since S326 phosphorylation of HSF1 was shown to increase HSF-1 transcriptional capacity, we also examined protein levels of HSP70, a classic downstream target of HSF1. Consistently, HSP70 protein levels decreased by 63%, 49% and 42% by the combined stress in SNU398, Hep3B and HepG2 cells. In SNU449 cells, which were slightly less sensitive to combined stress, there was little or no reduction in HSP70 expression. Other major heat shock proteins tested, including HSP60, HSP90, and HSP27, were unchanged in all treatments.

**Conclusions:** Consistent with observations in HepG2 and Hep3B cells, osmotic stress from 400 mOsm sodium acetate potentiated HS induced cell death additionally in SNU398 and SNU449 cells. Our data also suggest that sodium acetate enhanced HS induced cell death in most cases by inhibiting the cytoprotective response mediated by HSF1 and thus decreased subsequent HSP70 protein expression.
Early safety from a phase 1, multicenter, open-label clinical trial of talimogene laherparepvec (T-VEC) injected into liver tumors
S. Raman, M. Pless, A. Cubillo, A. Calvo, R. Hecht, C. Liu, E. Chan, J. Chesney, A. Prat; David Geffen School of Medicine, University of California, Los Angeles, CA, USA; Department of Oncology, Kantonsspital Winterthur, Winterthur, Switzerland; HM Universitario Sanchinarro, CIOCC, Madrid, Spain; Hospital General Universitario Gregorio Marañón, Madrid, Spain; Amgen Inc., Thousand Oaks, CA, USA; James Graham Brown Cancer Center, University of Louisville, Louisville, KY, USA; Hospital Clinic, University of Barcelona, Barcelona, Spain

Purpose: T-VEC is a genetically modified HSV-1 oncolytic immunotherapy designed to preferentially replicate in tumors, produce GM-CSF, and stimulate anti-tumor immune responses. This study evaluates the safety of intrahepatic injection (inj) of T-VEC in patients with hepatocellular carcinoma (HCC) or liver metastases (mets).

Materials: The primary objective is to assess the maximum tolerated dose. Eligible patients were ≥ 18 years (y) old, had progressive HCC or breast cancer (BC), colorectal cancer (CRC), gastroesophageal cancer, melanoma, non–small cell lung cancer, or renal cell cancer with liver mets, with measurable liver tumors suitable for inj. This dose escalation study comprised 2 groups: A (non-HCC) and B (HCC). T-VEC was given initially at 10^6 plaque-forming units (PFU)/mL followed by up to 4 mL of 10^7 PFU/mL (cohort 1) or 10^8 PFU/mL (cohort 2) every 21±3 days (Q21D), or up to 8 mL of the maximum tolerated concentration (MTC) Q21D (cohort 3). Inj volume was based on lesion size.

Results: Results from cohorts 1 and 2 of group A are reported. 14 patients were treated; 12 (3 BC, 9 CRC) were DLT-evaluable: Median age was 65.5 y (range, 33-73); median number of inj was 3; 1 pt received all 12 inj. MTC was 10^8 PFU/mL. There was 1 DLT, grade (G) 3 aspartate aminotransferase (AST)/G2 bilirubin increase (inc), after 1 dose. In all treated patients, 4 (28.6%) had G3/4 treatment-related adverse events (TRAEs); anemia and inc gamma-glutamyltransferase, alanine aminotransferase (ALT) and AST. There were 2 deaths, both attributable to disease. Incidence of serious AEs (SAEs) is shown (Table).

Conclusions: The MTC was 10^8 PFU/mL Q21D after initial inj at 10^8 PFU/mL. Repeated intrahepatic inj of T-VEC at the FDA-approved concentration for intralesional inj of melanoma was deemed tolerable and feasible in patients with liver mets. Additional investigation in combination with a PD-1 inhibitor is planned.

### DLT-Evaluable Pt Incidence of SAEs

<table>
<thead>
<tr>
<th>Event</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any SAE</td>
<td>6</td>
</tr>
<tr>
<td>Any TR SAE</td>
<td>2</td>
</tr>
<tr>
<td>Pyrexia</td>
<td>1</td>
</tr>
<tr>
<td>AST inc</td>
<td>1</td>
</tr>
<tr>
<td>Hernial eventation</td>
<td>1</td>
</tr>
<tr>
<td>Syncope</td>
<td>1</td>
</tr>
<tr>
<td>ALT inc</td>
<td>1</td>
</tr>
</tbody>
</table>

### (continued)

### Clear cell hepatocellular carcinoma is associated with non-viral cirrhosis and arterial-phase hypo-enhancement but does not predict outcome after locoregional therapy
B. Park, R. Gaba, Y. Huang, Y. Chen, G. Guzman, R. Lokken; University of Illinois Health, Chicago, IL

Purpose: Clear cell hepatocellular carcinoma (HCC) is a less common HCC cytologic variant associated with improved outcomes in studies prior to the advent of locoregional therapy (LRT). This study was undertaken to determine whether clear cell HCC predicts better outcomes after LRT.

Materials: We retrospectively identified 124 consecutive patients (92 men, 32 women; median age 59 y) with 132 HCC (mean diameter 4.8±3.9 cm) diagnosed by percutaneous biopsy between 2008-2017 prior to transarterial chemoembolization (TACE) (n=51, 41%), yttrium-90 radioembolization (n=17, 13%), percutaneous thermal ablation (n=41, 33%), and combination TACE/ablation (n=37, 29%). Baseline Barcelona Clinic Liver Cancer (BCLC) stage was 0A (n=48, 38%), B (n=33, 26%), C (n=27, 22%), and D (n=16, 13%). Cytological subtype was determined from percutaneous core needle biopsy as 100% clear cells, focal clear cells, or no clear cells. Baseline clinical and imaging features, and radiologic response by mRECIST were correlated with cytological subtype using multinomial regression analysis. Time to progression (TTP) and transplant free survival (TFS) were analyzed by Cox proportional hazard models.

Results: Percutaneous core biopsies comprised entirely of clear cell subtype were associated with non-viral etiologies of HCC (OR 5.3 95% CI 1.64-17.16; p = 0.005), solid histological arrangement (OR 4.32 95% CI 1.14-16.37; p = 0.031), and hypo-enhancement on arterial phase CT or MRI images (OR 3.08 95% CI 1.02-9.3; p = 0.046). The clear cell subtype was not associated with improved objective response by mRECIST (OR 0.93 95% CI 0.37-2.33; p = 0.87), delayed TTP (HR 1.17 95% CI 0.86-1.6; p = 0.32), or better TFS (HR 1.01 95% CI 0.69-1.47; p = 0.96) in comparison to specimens with focal or no clear cells. There remained no significant association between the clear cell subtype and TTP or TFS after stratifying by LRT modalities.

Conclusions: Clear cell HCC is more common in non-viral etiologies of cirrhosis and is associated with atypical enhancement on radiologic images. It does not, however, impart independent prognostic information prior to LRT.
Synthesis and in vitro evaluation of MRI visible resorbable and loadable microspheres for arterial embolization

L. Weng1, J. Zhang1, T. Pan1, R. Donelson1, M. Garwood1, J. Golzarian1; 1University of Minnesota, Minneapolis, MN

Purpose: To develop and evaluate the in vitro properties of MRI visible, resorbable and loadable microspheres for arterial embolization.

Materials: MRI visible microspheres were synthesized by incorporating superparamagnetic iron oxide (SPIO) nanoparticles (Feridex I.V., Ferumoxides injectable solution) into the carboxymethyl cellulose/carboxymethyl chitosan based bioreposable microspheres (BRMS). The size and appearance of these microspheres were examined with microscopy (CK-2, Olympus). The MR images of phantoms prepared with 2% agar were acquired on a 9.4T 31-cm MRI scanner (Agilent Technologies, Santa Clara, CA). Both multiband sweep imaging with Fourier transformation (MB-SWIFT) and gradient echo (GRE) images were acquired. Doxorubicin hydrochloride was used as a model drug to test the loading and release capabilities of these microspheres with the aid of a spectrophotometer (Beckman DU650) at 482 nm. Degradation of the doxorubicin loaded microspheres at 37 °C was monitored with an optical microscope.

Results: Under microscopy, these SPIO loaded BRMS appeared round in shape and yellow-brown in color with a size ranging from 100 to 1200 μm. For MRI imaging, GRE images only showed signal voids for all samples except for control (bland BRMS without SPIO). However, the T1 positive contrast in the MB-SWIFT image between these samples was much more evident than in the control image. The T1 relaxation rate (R1) of the samples was enhanced from 0.65 s-1 to 2.08 s-1 when the iron concentration was increased from 0 mg/mL to 2 mg/mL. Drug loading of SPIO loaded BRMS was successfully performed by directly immersing them in a 25 mg/mL doxorubicin hydrochloride solution, and reached 99.49% after 2 hours. Under static medium conditions, the drug loaded MRI visible BRMS gradually released doxorubicin in 0.01 M PBS, starting with a relatively fast 24-hour initial release phase, followed by a second much slower release phase. The percentage of drug released was 9.18 ± 0.39% at 24 hours. At day 13, the doxorubicin loaded microspheres had degraded into small pieces in PBS at 37 °C.

Conclusions: SPIO loaded BRMS were successfully prepared and were visible by MRI and these microspheres were drug loadable and degradable.

Sorafenib combined with drug-eluting bead transarterial chemoembolization for the treatment of advanced hepatocellular carcinoma with intrahepatic vascular shunts: the imaging prognostic factors related to patient survival

M. Tsai1, Y. Shih2, P. Chang3, H. Fan3, W. Chang4, Y. Chou5, H. Hsu3; 1Tri-Service General Hospital and National Defense Medical Center, Taipei City, Taiwan; 2Tri-Service General Hospital and National Defense Medical Center, Taipei, Neihu Dist; 3Tri-Service General Hospital and National Defense Medical Center, Taipei, Neihu Dist; 4Tri-Service General Hospital and National Defense Medical Center, Taipei, Neihu Dist; 5National Defense Medical Center, Taipei, Neihu Dist

Purpose: To determine which imaging prognostic factors affecting the patient survival in advanced-stage hepatocellular carcinoma (HCC) with intrahepatic vascular shunts treated by a combination therapy of sorafenib and drug-eluting bead transarterial chemoembolization (DEB-TACE).

Materials: We performed a retrospective review of 55 advanced-stage HCC patients treated with a combination therapy of sorafenib and DEB-TACE from October 2013 to December 2016, and 29 (52.7%) were associated with intrahepatic vascular shunts. We recorded tumor response to treatment with post-TACE CT within 2 months including the tumor characteristics (size, number, and attenuation) and residual tumor changes, alteration of arterial enhancing ratio, progression or reduction of intrahepatic vascular shunts and thrombosis. Findings were correlated to 6-month survival, and inter-observer variability was assessed. Follow-up after DEB-TACE ranged from 1 to 42 months.

Results: Advanced HCC with intrahepatic vascular shunts treated by a combination therapy of sorafenib and DEB-TACE (n=29) had a significantly worse survival rate than those without intrahepatic vascular shunts (P < 0.05). In this group, post-TACE CT findings of decreased tumor size ≥ 20% (n = 18/22, or 81.8% versus 2/8, or 25.0%, P <0.05), drop of arterial enhancing ratio ≥ 50% (n = 18/22, or 81.8% versus 3/8, or 37.5%, P <0.05), and lack vascularization of the hepatic vascular thrombus (n = 15/22, or 68.2%, versus 1/8, or 12.5%, P <0.05) were contributed to a survival benefit. Of these findings, decreased tumor size ≥ 20% (hazard ratio [HR], 0.17, P <0.001) and drop of arterial enhancing ratio (HR, 0.32, P <0.05) independently predicted a better survival. All the CT findings showed moderate to almost perfect inter-observer agreement (0.71-0.87).

Conclusions: For advanced HCC patients with intrahepatic vascular shunts treated by sorafenib and DEB-TACE, post-TACE findings of decreased tumor size ≥ 20% and drop of arterial enhancing ratio ≥ 50% independently predicted a better survival.

Updated overall survival (OS) analysis from the international, phase 3, randomized, placebo-controlled RESORCE trial of regorafenib for patients with hepatocellular carcinoma who progressed on sorafenib treatment

Guohong Han1, Philippe Merle2, Alessandro Granito3, Yi-Hsiang Huang4, Gyorgy Bodoky5, Osamu Yokosuka6, Olivier Rosmorduc7, Valeriy Breder8, René Gerolami9, Gianluca Masì10, Paul J. Ross11, Shukui Qin12, Tianqiang Song13, Jean-Pierre Bronowicki14, Isabelle Ollivier-Hourmand15, Masatoshi Kudo16, Christelle LeBerre17, Annette Baumhauer18, Gerald Meinhardt19, Jordi Bruix20, on behalf of the RESORCE Investigators; 1Department of Liver Disease and Digestive Interventional Radiology, National Clinical Research Center for Digestive Disease, Xijing...
Purpose: The phase 3 RESORCE trial showed that regorafenib improved the primary endpoint of OS versus placebo in patients with unresectable HCC who progressed during sorafenib treatment. Secondary endpoints of progression-free survival, time to progression, disease control rate, and objective response rate were also improved with regorafenib (Bruix, et al. Lancet 2017). Adverse events were consistent with the known safety profile of regorafenib. We report updated OS results from RESORCE.

Materials: Patients with Barcelona Clinic Liver Cancer stage B or C HCC with radiologic progression on sorafenib, Child–Pugh A liver function, and Eastern Cooperative Oncology Group performance status 0–1 were randomized 2:1 to regorafenib 160 mg/day or placebo for Weeks 1–3 of each 4-week cycle until progression, death, or unacceptable toxicity. The data cut-off for the primary analysis was February 29, 2016; the data cut-off for this updated OS analysis was January 23, 2017. Hazard ratios (HRs) and 95% confidence intervals (CIs) were derived using the Cox model.

Results: The updated HR for OS was similar to that of the primary OS analysis (Table). Estimated OS rates (regorafenib vs placebo) at 12, 18, and 30 months were 47% versus 28%, 32% versus 16%, and 16% versus 7%, respectively. Results for OS favored regorafenib in all preplanned subgroup analyses.

Conclusions: The results of this updated OS analysis with a longer follow-up from the RESORCE trial confirm the results of the primary OS analysis, showing that regorafenib is an effective treatment option for patients with HCC who progress on prior sorafenib treatment.

### 4:21 PM Abstract No. 277

**TIVAD placement at a tertiary cancer care center: A single institutional experience**

I. Sullivan1, W. Ryan2, K. Panzer2, V. Rivera2, S. Nguyen2, D. Yu2, X. Lu2, R. Cobb2, G. Cohen1, M. Burstheyn1; 1Temple University Hospital, Philadelphia, PA; 2Lewis Katz School of Medicine at Temple University, Philadelphia, PA

**Purpose:** To retrospectively evaluate the effect of patient risk factors and operator insertion techniques on the complication rate of totally implantable venous access devices (TIVADs), also known as chest ports.

**Materials:** A retrospective, IRB approved analysis of all patients who received a Dignity® chest port via trans-jugular approach between July of 2013 and September of 2017 was performed (n = 2119; 829 males, 1290 females, median age of 63, range of 19-89). Patient demographics including age, gender, BMI and malignancy type were collected. Procedural data including laterality and reservoir position (above or below the incision). Complication odds ratios for cohorts were calculated and compared using Fisher’s Exact and Wald Chi-Square tests. For the purposes of our study a complication was defined as an unanticipated event requiring the removal of the device.

**Results:** 69 (3.3%) of 2119 patients had 2 (n = 66) or 3 (n = 3) port placements for a total of 2145 port placements. Using data from the first placement within our study’s timeframe for each patient, overall complication rate was 3.2% (68/2119). Complication rate for less than 30 days post procedure was 0.76%. Infection was the most common complication (n=29), followed by dehiscence (n=20). Complications were significantly more common in females than males with normal BMI (OR=3.12, p=0.03). The effect of gender on complication rate was not significant in underweight (p=0.18), overweight (p=0.42) or obese individuals (p=0.096). Age did not impact complication rate (p=0.18). Complications were most common among patients with sarcomatous malignancies (OR=8.27 vs. gastrointestinal, p<0.001 for comparing all pathology categories). Port laterality (p=1.00) and reservoir position (above or below the incision) (p=0.26) did not have significant effects on complication rate.

**Conclusions:** In individuals with normal BMI the effect of gender on port complication rate may be explained by difference in breast size. The greater incidence of complications in sarcoma patients may be attributed to highly corrosive chemotherapy regimens. The variables of operator technique and port laterality were not impactful.

<table>
<thead>
<tr>
<th>Primary Analysis</th>
<th>Updated Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OS</strong></td>
<td><strong>OS</strong></td>
</tr>
<tr>
<td>Patients with event, n (%)</td>
<td>Regorafenib (n = 379)</td>
</tr>
<tr>
<td>Median OS (95% CI), months</td>
<td>233 (61)</td>
</tr>
<tr>
<td>HR (95% CI); 1-sided P value</td>
<td>10.6 (9.1, 12.1)</td>
</tr>
<tr>
<td>0.62 (0.50, 0.78); &lt;0.0001</td>
<td>0.61 (0.50, 0.75); &lt;0.0001</td>
</tr>
</tbody>
</table>
3:00 PM  Abstract No. 386

Viabahn VBX as a novel bridging stent graft (BSG) for fenestrated and branched endovascular abdominal aortic aneurysm repair (FB-EVAR)

E. Tarulli1, O. Mironov2, S. Mafeld3, G. Annamalai4, K. Tan5; 1University of Toronto, Toronto, OR; 2University of Toronto, Toronto, ON; 3JDMI, Toronto General Hospital, Toronto, ON; 4Mount Sinai Hospital and University Health Network, Toronto, ON; 5University of Toronto, Toronto, Ontario

Purpose: To evaluate the feasibility and safety of a novel balloon-expandable, heparin bonded endoprosthesis [Viabahn VBX, W.L Gore and Associates, USA] when used as the bridging stent graft (BSG) with fenestrated and branched endovascular repair of abdominal aortic aneurysms (FB-EVAR). FB-EVAR and BSGs increase repair complexity and potential sites for endoleak, stenosis, thrombosis and graft migration. Potential advantages of the Viabahn VBX include precise balloon mounted deployment, improved trackability and post-deployment flexibility due to lack of longitudinal stent struts and anti-thrombogenic properties due heparin coating on the luminal surface. The efficacy, safety and clinical outcomes were assessed.

Materials: Research ethics board approved, prospective, single arm cohort, pilot study of patients undergoing FB-EVAR between February 22 and Aug 30, 2017. FB-EVAR was performed per the standard institutional protocol by a team composed of vascular surgeons and interventional radiologists. Viabahn VBX endografts were used for all intended visceral branches as long as appropriately sized devices were available (Investigator Exemption Study Authorization from Health Canada). Follow-up CTA at 1 week, 6 weeks, 6 months and 1 year. Patient characteristics, procedural details, technical and clinical outcomes were reviewed.

Results: FB-EVAR was performed in 9 patients (8 male) median age 78, mean aneurysm diameter 6.6 cm with 5 infrarenal, 2 type III, 1 type IV and 1 type V (Crawford). There were 6 fenestrated and 3 branch grafts. 97% of stents successfully deployed and patent at first follow-up (30 of 31). Fenestrated BSGs were flared at the junction to the main body. Endoleaks occurred in 3 of 9 patients, 1 type Ib, 1 type II, 1 type III. 2 patients required reinterventions 1 to extend a right renal BSG into the main body and 1 type II endoleak embolization. 1 patient was readmitted with GI bleed requiring surgery, 1 developed paraparesis and 1 paraplegia (both within 48 hours post procedure). Mean clinical follow-up was 51 days.

Conclusions: The Viabahn VBX stent is a safe and effective BSG for FB-EVAR with no early stent thrombosis. Further study is required to determine longer-term stent efficacy.

3:10 PM  Abstract No. 381

Percutaneous ultrasound-guided insertion of distal perfusion sheaths for patients with limb ischaemia during femo-femoral venoarterial-ECMO: a retrospective study of 92 cases

K. Zhuang1, C. Png2, E. Allan3, S. Leong1, F. Irani4, S. Chandramohan1, K. Damodharan4, N. Kumar3, K. Tay1, M. Chakaramakkil4, A. Patel1; 1Singapore General Hospital, Singapore, Singapore; 2University of Aberdeen, Aberdeen, UK; 3University College London, London, UK

Purpose: Extracorporeal life support has become an established tool used during resuscitation. Peripheral VA-ECMO is useful in an intensive or emergent care setting but carries a significant risk of complications during cannulation and ongoing maintenance. A well-documented complication of transfemoral-placed ECMO is lower limb ischemia which can be treated by various distal perfusion adjuncts. This report describes our experience of using percutaneously inserted sheaths to reinstate lower limb perfusion in patients with clinical suspicion of ipsilateral lower limb ischemia during femo-femoral VA-ECMO.

Materials: A retrospective review of peripheral VA-ECMO cases in the National Heart Centre Singapore and Singapore General Hospital from January 2013 to December 2016 was performed. Patients with distal perfusion sheaths inserted by interventional radiology (IR) were included in the study. Data collected included patient demographics, comorbidities, indication and duration of ECMO, 30-day mortality, technical success of sheath insertions and arterial complications of the lower limb.

Results: There were 170 cases of peripheral VA-ECMO were identified. Patients with distal perfusion sheaths inserted by IR in 57 cases. Technical success rate of percutaneous insertion was 93.0% and there was documented evidence of improved perfusion in 68.4%. Limb-related complications occurred in 28.1%. The 30-day mortality was 63.3%. The mortality rate of patients with limb-related complications was higher compared to those without complications at 87.5% and 58.1% respectively (RR = 1.51, p < 0.01).

Conclusions: Distal limb ischemia is a well-known complication of femo-femoral VA-ECMO and can be managed by percutaneous ultrasound-guided insertion of a distal sheath in the proximal SFA for perfusion via the ECMO circuit.

3:20 PM  Abstract No. 382

Comparison of particulate embolization after femoral artery treatment with IN.PACT Admiral, Ranger, and Stellarex paclitaxel-coated balloons in healthy swine

R. Virmani1, A. Finn1; 1CV Path, Gaithersburg, MD

Purpose: Different excipient/drug formulations unique to individual drug-coated balloons (DCBs) may influence embolic safety characteristics in distal non-target peripheral vascular territories through embolization of released particulates. A comparator study of three DCBs in commercial use, IN.PACT Admiral, Boston Scientific Ranger, and Spectranetics Stellarex, in healthy swine was
therefore performed to assess which balloon produces more downstream emboli and tissue reaction.

**Materials:** Three times over-lapping 80-mm DCBs for each device were assessed in 24 femoral arteries of 12 swine with 28-day follow-up for downstream embolic events and debris. IN.PACT Admiral was used as a control as its downstream emboli and effect has been previously studied and published. Histologic analysis of arterial wall and skeletal muscle and coronary band downstream from the external or internal femoral arteries was performed. This analysis was supported by an analytic measurement of paclitaxel levels. The gastrocnemius, gluteal, and gracilis are skeletal muscle territories distal to the external femoral artery and the coronary corium (i.e. Coronary band) is a highly vascularized structure that gives rise to the outer layers of the hoof wall and resembles the nail bed of a human finger.

**Results:** For all DCBs tested, regions of increased proteoglycan were accompanied by the loss of medial SMCs mainly extending nearly one-third to complete transmural involvement with restricted circumferential extension. Medial fibrin was present for all cohorts. The percentage of sections with downstream vascular changes in arterioles were greatest for IN.PACT > STELLAREX > RANGER (43%, 36%, and 25% respectively). Embolic crystalline material was seen for all cohorts and followed a similar trend.

**Conclusions:** All DCBs tested exhibited downstream effects of paclitaxel drug and/or downstream emboli. The potential downstream embolic effects with certain DCB use may present a concern that may influence the selection of available catheter technologies.

### Abstract No. 383

**Snuff box radial artery access for arteriovenous fistula intervention**

J. Hull	extsuperscript{1}, S. Workman	extsuperscript{1}; \textsuperscript{1}Richmond Vascular Center, North Chesterfield, VA

**Purpose:** To compare snuff box radial artery access (SBRA) with direct fistula access (DFA) for radiocephalic fistula intervention.

**Materials:** Retrospective chart review of 69 consecutive radiocephalic interventions between April 2013 and April 2017 was performed. The snuff box radial access was performed under ultrasound guidance with the hand in a neutral position (thumb up). The SBRA artery was entered distal to the extensor pollicis longus, over the trapezium bone. Radial artery sheaths were used for SBRA (6 and 7 Slender, Terumo, Tokyo, Japan). Post procedure hand held pressure was applied for hemostasis. The indications, success and complications of SBRA access procedures were reviewed.

**Results:** SBRA was used in 25% (17/69) of radiocephalic fistula interventions. Technical and procedural success was 100% for both SBRA (17/17) and DFA (52/52). Procedures performed from SBRA included 9 balloon dilations of juxtaanastomotic fistulae, 3 balloon assisted maturations, two embolizations and one fistula declot. DFA was used for lesions not involving the juxtaanastomotic segment. Mean time to hemostasis and discharge were increased in the SBRA group with 13.4 ± 4.3 min (range, 6-20) versus 10.2 ± 5.5 min (range, 5-35) (p<0.02) and 37.1 ± 12.8 min (range, 15-65) versus 31.0 ± 13.1 min (range, 15-75) (p<0.05) compared with the DFA group. Minor hematoma occurred in 12% (2/17) of SBRA and 2% (1/52) of DFA group. There were no major complications.

**Conclusions:** SBRA was successfully used for radiocephalic fistula intervention with low complications, and with minimally increased hemostasis and recovery times compared with DFA.

### Abstract No. 385

**Embolization of residual endoleak or false aneurysm after surgical or endovascular repair of the ascending aorta**

X. Kos	extsuperscript{1}, P. Revel-Mouroz	extsuperscript{2}, O. Meyrignac	extsuperscript{2}, F. Mokrane	extsuperscript{2}, H. Bertoni	extsuperscript{3}, H. Rousseau	extsuperscript{2}; \textsuperscript{1}Cardiac and Medical Clinic of Aressy, Pau, Aquitaine; \textsuperscript{2}Rangueil University Hospital Center, Toulouse, France; \textsuperscript{3}University Hospital Center, Buenos Aires, Argentina

**Purpose:** To illustrate with 3 patients the feasibility of endovascular and direct percutaneous embolization of complications following ascending aorta surgery and TEVAR, with contra-indication for conventional reintervention.

**Materials:** 3 patients have been treated for complications of ascending aortic repair. Patient 1 presented type A dissection after surgical aortic valve replacement. Patient 2 presented type 3 endoleak after endovascular aortic arch repair with a bi-carotid
branched Stent-Graft. Patient 3 presented a false aneurysm of the ascending aorta following Bentall surgery.

**Results:** Endovascular access has been used in 2 cases, while direct percutaneous access for the double branch Stent-Graft. Embolization was performed using Penumbra coils. Procedural details are illustrated. Follow-up angiogram and CT-scanner showed a complete occlusion in all 3 patients. No significant complications have been observed during the procedure and the close follow-up.

**Conclusions:** Embolization after TEVAR or surgical repair of the ascending aorta can be an effective complementary treatment of endoleak or false aneurysm complications. Multidisciplinary decision is mandatory.

---

**4:00 PM**

**Abstract No. 380**

**Vacuum-assisted suction thrombectomy (VAST) for the treatment of acute peripheral arterial thromboembolism**

M. Kotarska1, R. Riaz2, B. Arslan3, U. Turba4, J. Tasse5, S. Madassery6, O. Ahmed7; 1Rush Medical Center, Chicago, IL; 2Rush University Medical Center, Willowbrook, IL; 3Rush University Medical Center, Chicago, IL; 4RUSH University Medical Center, Chicago, IL; 5Rush University Medical Center, Chicago, IL; 6Rush University Medical Center, Rush Oak Park Hospital, Glenview, IL; 7Rush University Medical Center, Northbrook, IL

**Purpose:** To evaluate the safety and efficacy of vacuum-assisted suction thrombectomy (VAST) for treating acute arterial thromboembolism in the lower extremities.

**Materials:** Single-institution retrospective review between May 2013 and July 2017 of all arterial thromboembolic interventions using the Penumbra Indigo aspiration catheter for VAST. The Indigo® catheter was used as either a primary method for thrombectomy (n = 42) or as an adjunct to catheter-directed thrombolysis (n = 41). Technical outcomes were graded on angiography as complete (100% thrombus clearance), partial (<100%), or no response (0%). Patient demographics, indication for treatment, procedural variables, and immediate or delayed complications were recorded.

**Results:** 97 lower extremity vessels in 83 patients were treated by VAST for above-the-knee (n = 10), below-the-knee (n = 67), or bypass graft (n = 20) interventions. Treated arteries included the common iliac (n = 1), common femoral (n = 4), superficial femoral (n = 5), popliteal (n = 13), anterior tibial (n = 16), posterior tibial (n = 15), peroneal (n = 17), dorsalis pedis (n = 5), and dorsal metatarsal (n = 1). 20 bypass grafts were also treated. Restored patency to the target vessel was achieved as complete, partial, or no angiographic response in 56 (58%), 32 (33%), and 9 (9%) cases respectively. Complete response in all above-the-knee interventions was 0% (0/10) and ultimately required adjunct catheter-directed thrombolysis for definitive treatment. 72% (47/65) of below-the-knee and 60% (12/20) of bypass graft VAST procedures resulted in complete response. 50% (5/10) of above-the-knee, 23% (15/65) of below-the-knee and 30% (6/20) of bypass graft VAST procedures resulted in partial response. During VAST, 10 (10%) instances of distal clot migration were observed, of which 8 were treated definitively by VAST to the migrated vessel during the same procedure. No other device related complications occurred.

**Conclusions:** VAST using the Indigo® aspiration catheter is a safe and effective device for managing arterial thromboembolism in the lower extremities. Below the knee thrombectomy was associated with the highest rates of complete thrombus clearance.

---

**4:10 PM**

**Abstract No. 388**

**Ethylene vinyl alcohol copolymer (Onyx) for treatment of large venous vascular malformations: long-term results**

A. Gomes1, P. Monteleone1, A. Vasan2, S. Bukata3, G. Fishbein1, M. Fishbein1, J. Sayre1; 1David Geffen School of Medicine at UCLA, Los Angeles, CA; 2Duke School of Medicine, Durham, NC; 3David Geffen School of Medicine at UCLA, Santa Monica, CA

**Purpose:** To describe the long-term results and advantages of ethylene vinyl alcohol polymer for treatment of venous vascular malformations.

**Materials:** Since 2005, we have used Ethylene vinyl alcohol copolymer (Onyx 18 & 34) in the treatment of 62 patients with large, low-flow venous vascular malformations. There were 34 females and 28 males with ages ranging from 7–59 years (mean 25 years). Fifty-one of the malformations involved the extremities and 11 involved the chest, abdominal wall or pelvis. All patients were evaluated with MRI/MRA pretreatment. Onyx was delivered by direct injection with ultrasound and fluoroscopic guidance under tourniquet control. In a few cases Onyx was also delivered via a transarterial micro catheter positioned in large feeding vessels. Sodium tetradecyl (3%) foam was used also in conjunction with Onyx in six patients where there were associated smaller foci of malformation. Histologic examination of tissues from patients whose embolized lesions were subsequently explanted was performed.

**Results:** Ethylene vinyl alcohol copolymer (Onyx) was found to be useful for occlusion of large venous channels in venous malformations. Unlike sclerosing agents, its visibility allowed direct observation of filling of the venous malformation during injection. When used alone, there was minimal post procedure discomfort. There were two complications: one extrusion of Onyx from a lesion on the sole of the foot, which healed without sequelae and one instance of embolization of a small Onyx fragment to the lung, also without sequelae. On H & E stains, the Onyx was noted to be distributed in the intraluminal spaces with associated mild foreign body type giant cell reaction. Permanency of the copolymer was demonstrated on long-term imaging follow-up.

**Conclusions:** Ethylene vinyl alcohol copolymer (Onyx) is a safe, durable agent for treatment of venous vascular malformations. It is of particular value in malformations with large venous channels. Unlike standard sclerosing agents, Onyx behaves as a filler, and is not dependent upon generation of an inflammatory reaction for occlusion. Its opacity allows visualization of filled channels. It can be used alone or in conjunction with sclerosing agents.
Percutaneous sclerotherapy of slow-flow vulvar vascular malformations
A. Parvinian1, E. Bendel1, H. Bjarnason1; 1Mayo Clinic, Rochester, MN

Purpose: To assess the safety and efficacy of percutaneous sclerotherapy of slow-flow vulvar vascular malformations.
Materials: An IRB-approved retrospective review was undertaken of all patients who underwent percutaneous sclerotherapy of slow-flow vulvar vascular malformations between January 2008 and August 2017. Patient demographics, lesion characteristics, procedural factors, and clinical outcomes were identified through a review of the electronic medical record and relevant imaging.

Results: Seven female patients (ages 7-32 years) with slow-flow vulvar vascular malformations underwent a total of 14 percutaneous sclerotherapy treatments using the 3% sodium tetradecyl sulfate foam technique. Two cases were associated with Klippel-Trenaunay syndrome and one with Servelle-Martorell syndrome. Presenting symptoms included generalized pain or discomfort (n = 6), dyspareunia (n = 1), voiding difficulties (n = 1), and cosmetic concerns (n = 1). All sclerotherapy procedures were technically successful. Clinical follow-up was available in six patients. Two patients reported near-complete resolution of symptoms after a single treatment. Three patients experienced initial relief but developed symptomatic recurrence after one year and required repeat treatment with subsequent resolution of symptoms. One patient experienced a gradual improvement in symptoms requiring a total of five treatments. One procedure (7.1%) resulted in minor labial cutaneous ulceration which resolved with conservative management. There were no major complications.

Conclusions: Percutaneous sclerotherapy of slow-flow vulvar vascular malformations proved safe and effective in this limited cohort. While repeat therapy was necessary in the majority of cases, nearly all patients experienced durable symptomatic relief.

Scientific Session 40
Ablation: Liver 2
Wednesday, March 21, 2018
3:00 PM–4:30 PM
Room: 409B

SBRT versus thermal ablation for treatment of hepatocellular carcinoma: impact on the MELD score in cirrhotic patients
D. Johnson1, Q. Wang2, S. Perkins3, J. Ronald4, C. Kim5; 1Duke University, Durham, NC; 2Duke Univ/ Huazhong University of Science and Technology, Durham, NC; 3Grand Strand Medical Center, Myrtle Beach, SC; 4Duke University Medical Center, Durham, NC

Purpose: Thermal ablation for the treatment of HCC has been established as a curative treatment for tumors of appropriate size and location. SBRT is a relatively new therapy for HCC that has shown promise in tumor control. While short-term toxicities are known, the long-term effects on liver function related to collateral radiation is not yet well understood. The purpose of this study was to compare the changes in the MELD score over time, as a measure of liver functionality.

Materials: We reviewed our institutional database for patients undergoing SBRT or thermal ablation for the treatment of HCC for patients with tumor size less than 5 cm, who also had adequate pre- and postprocedural laboratory follow-up, and lack of subsequent therapy within 6 months. Analysis was performed on 20 patients who underwent SBRT and 38 patients who underwent thermal ablation. The MELD score was calculated based on preprocedure lab values as well as values at 1, 6, and 12 months after treatment. Changes from pretreatment to post treatment intervals were calculated using the Wilcoxon signed rank test. Absolute differences were compared using the Wilcoxon rank sum test.

Results: Patients undergoing SBRT were significantly older than those undergoing thermal ablation (70.4 vs 63.9 years, p = 0.02) and had significantly larger mean tumor size (3.0 vs 2.1, p<0.01). The mean baseline MELD scores were 9.1 and 9.7, respectively. Comparing the pretreatment MELD score to post treatment scores at 1, 6, and 12 months, the mean change with SBRT was a 0.7, 1.5, and 2.6 point increase, respectively (p = 0.03 at 12 months). For ablation, the changes were 0.3, 0.7, and 0.3, respectively (p = NS for all). The absolute change in MELD from pretreatment to 12 months was significantly higher for SBRT than ablation (p = 0.04).

Conclusions: In patients undergoing local therapy for HCC under 5 cm, SBRT was associated with significantly higher increases in their MELD score at 1 year posttreatment compared to percutaneous thermal ablation. However, given the limited samples size and differences in patient age and tumor size, additional studies with larger cohorts are warranted to fully understand late-term hepatotoxicities.

3:10 PM
Abstract No. 391

Poor histologic differentiation of hepatocellular carcinoma is associated with high-risk clinical features and infiltrative phenotype in patients treated with locoregional therapies
B. Park1, R. Gaba1, Y. Huang1, Y. Chen1, G. Guzman1, R. Lokken1; 1University of Illinois Health, Chicago, IL

Purpose: Hepatocellular carcinoma (HCC) histological grade impacts survival after liver transplantation, but its prognostic significance in more advanced-stage patients treated with locoregional therapy (LRT) is unclear. This study was undertaken to assess the relationship between histological grade and baseline clinical stage, CT and MRI features, and outcomes in patients with HCC treated with LRT.

Materials: We retrospectively identified 124 consecutive patients (92 men, 32 women; median age 59 y) with 132 HCC (mean diameter 4.8 ± 3.9 cm) diagnosed by percutaneous biopsy between 2008-2017 prior to transarterial chemoembolization (TACE)
(n = 51, 41%), yttrium-90 radioembolization (n = 17, 13%), percutaneous thermal ablation (n = 41, 33%), and combination TACE/ablation (n = 15, 12%). Baseline Barcelona Clinic Liver Cancer (BCLC) stage was 0/A (n = 48, 38%), B (n = 33, 26%), C (n = 27, 22%), and D (n = 16, 13%). Histological Edmondson-Steiner (ES) grade was correlated with baseline imaging, clinical features, and radiologic response by mRECIST using binary regression models. Time-to-progression (TTP) and transplant-free survival (TFS) were compared by ES grade using Cox proportional hazard models.

**Results:** Tumors were ES grade 1 (n = 13, 10%), 2 (n = 94, 76%), or 3 (n = 16, 13%). Compared to low ES grades (1/2), high ES grade (3) was associated with serum AFP>50 ng/ml (OR 4.62 95% CI 1.53-13.97; P = 0.007), advanced BCLC stage (OR 4.54 95% CI 1.26-16.38; P = 0.02), tumor diameter >5 cm (OR 3.12 95% CI 1.08-9.01; P = 0.04), and infiltrative phenotype (OR 4.98, 95% CI 1.53-16.19; P = 0.008). Serum AFP, advanced BCLC stage, and tumor diameter were associated with reduced TTP and survival (P<0.05). High ES grade was not associated with differences in objective response (OR 2.47 95% CI 0.73-8.36; P = 0.15), TTP (HR 1.45 95% CI 0.68-3.08; P = 0.34), or TFS (HR 0.97 95% CI 0.34-2.75; P = 0.95) compared to low ES grade when stratified by type of LRT.

**Conclusions:** Poor histologic differentiation is associated with aggressive tumor features but does not provide independent prognostic information when adjusting for LRT modality. These results support deferral of biopsy of HCC diagnosed by imaging criteria prior to LRT.

### 3:20 PM Abstract No. 392

**FEATURED ABSTRACT**

**Non-thermal, non-invasive hepatic ablation using robotically assisted sonic therapy (RAST): ablation creation and imaging characteristics**

A. Smolock1, M. Cristescu2, C. Green3, K. Longo3, E. Vlaisavljevic4, J. Cannata5, L. Mankowski-Gettle5, M. Lubner3, J. Hinshaw3, Z. Xu6, T. Ziemlewicz3, F. Lee3, 1University of Pennsylvania, Philadelphia, PA; 2Mount Sinai Hospital, New York, NY; 3University of Wisconsin, Madison, WI; 4Virginia Tech University, Blacksburg, VA; 5HistoSonics, Inc., Ann Arbor, MI; 6University of Michigan, Ann Arbor, MI

**Purpose:** Robotically assisted sonic therapy (RAST) is a method of non-invasive focused ultrasound ablation using the technology of histotripsy to controllably fractionate tissue without skin punctures or thermal energy. The purpose of this study was to determine the feasibility of creating hepatic ablations with RAST and to define the MRI characteristics of the ablation zones.

**Materials:** RAST was performed in the normal liver of 18 female swine under general anesthesia using a 700 kHz therapy transducer at 240-300 PRF for a 3 cm prescribed spherical volume. MRI of the liver was performed immediately after RAST in all animals. Nine of 18 animals were subsequently sacrificed, and the remaining were survived for 4 weeks and reimaged by MRI prior to sacrifice. One pig was euthanized at 2 weeks due to an unrelated enteritis. Livers were harvested for histopathology. Pre- and post-gadoxetic acid 3T MRI sequences were reviewed for qualitative and quantitative measures of ablation imaging. Data was analyzed with student’s t test for continuous variables and Friedman rank sum test for categorical data.

**Results:** Mean ablation diameter on immediate post-ablation MRI was 3.4 ± 0.7 cm. The greatest deviation between prescribed and actual ablation diameter was in the cranio-caudal dimension, likely a result of respiratory motion. Ablation volume decreased by approximately 50% over the 4-week follow-up period. Body wall injuries were identified in 11/18 animals. Ablation zones demonstrated heterogeneous T1 and T2 signal on MRI, and a multireader analysis determined post-contrast portal venous and hepatobiliary phase sequences to be best for visualization and margination of the ablation zone. Histopathology demonstrated complete destruction of tissue within the ablation zone with a narrow surrounding zone of partial necrosis and development of a fibrous capsule at the 4-week follow-up time.

**Conclusions:** RAST can produce hepatic ablations that closely correlate with prescribed treatment volumes, are easily visualized on MRI, and demonstrate complete tissue destruction. Given the feasibility of producing adequate hepatic ablations, additional work to optimize treatment parameters and minimize body wall injuries is warranted.

### 3:30 PM Abstract No. 393

**FEATURED ABSTRACT**

**Ablation of colorectal liver metastases by irreversible electroporation: final results of the COLDFIRE-2 Trial**

L. Vroomen1, A. Ruarus2, H. Scheffer3, C. van Kuijk2, P. van den Tol2, M. Meijerink4; 1VU University Medical Center, Amsterdam, Noord-Holland; 2VU University Medical Center, Amsterdam, Noord-Holland; 3VU University Medical Center, Amsterdam, Noord-Holland; 4VU University Medical Center Amsterdam, Amsterdam, Noord-Holland

**Purpose:** To investigate the safety and efficacy of irreversible electroporation (IRE) for colorectal liver metastases (CRLM) that are contraindicated for surgical resection and thermal ablation because of safety or efficacy concerns.

**Materials:** In this prospective, single-arm, phase-II trial 40 patients with CRLMs ≤ 3.5 cm were treated with IRE. Adverse events (AEs) were graded according to the Common Terminology Criteria for Adverse Events (CTCAE) 4.0. Three-monthly 18F-FDG PET-CT, contrast-enhanced CTs and MRIs were made to detect disease progression. Kaplan-Meier estimates were used for survival analysis.

**Results:** IRE was successfully performed in all 40 patients (49 CRLMs). There were no IRE related deaths. There were 10 minor AEs (grade I or II) and nine major complications (seven grade III, two grade IV). After a median follow-up of nine months (range, 0-34 months), eight lesions showed an...
Histological correlation of histotripsy-induced tissue destruction with acoustic-based feedback

J. McAskey1, X. Zhang1, T. Hall1, J. Shi1, E. Vlaisavljevich2, F. Lee3, C. Cain1, Z. Xu1; 1University of Michigan, Ann Arbor, MI; 2Virginia Tech University, Blacksburg, VA; 3University Of Wisconsin, Madison, WI

Purpose: Histotripsy is a noninvasive, non-thermal ultrasound ablation technique that uses high-pressure, microsecond-long pulses to generate acoustic cavitation to destroy cells in target tissues. With increasing number histotripsy pulses (i.e., dosage), the target tissue is gradually fractionated into a liquefied homogenate with no viable cells. As the target tissue becomes more fractionated, the cavitation-induced motion in the tissue changes, which can be detected with an ultrasound imaging feedback technique called bubble-induced color Doppler (BCD). This study analyzes the histological changes during histotripsy therapy and their correlations with BCD.

Materials: A 112-element, 500-kHz phased histotripsy array is used to generate volumetric lesions within ex vivo bovine liver with dosages between 30 and 1000 pulses-per-location. An L7-4 ultrasound probe is used to acquire BCD signals during all. The linear correlations between the change in BCD and three histological analytics are calculated. Histological metrics used in this study represent weak (viable cell count), moderately strong (remaining reticulin-stained type III collagen), and strong (remaining trichrome-stained type I collagen) components of liver tissue, respectively.

Results: All BCD measurements indicated a mono-directional increase in tissue motion with increasing fractionation. Histological analysis revealed that hepatocytes are destroyed first during histotripsy therapy within the first 200 pulses (<3 min), followed by reticulin-stained type III collagen around 300-500 pulses (10-20 min), and finally trichrome-stained type I collagen between 500-1000 pulses (20-40 min). Only mild portal tract destruction was observed within the first 200 pulses. The change in BCD experienced a statistically significant (p<0.001) linear correlation with type III collagen destruction, indicating that structural components directly affect cavitation-induced tissue motion.

Conclusions: We investigated the progression of histotripsy-induced tissue destruction from a histological perspective and found that ablation of structural components correlated with changes in cavitation-induced tissue motion detected as real-time ultrasound imaging BCD feedback.

Comparison of alcohol ablation and radiofrequency ablation for treatment of hepatocellular carcinoma: A retrospective analysis of long-term overall and disease-free survival

J. Bautista1, S. Phung2, I. Nguyen3, E. Nguyen4, D. Der1, G. Vatakencherry5, C. Lam6; 1Kaiser Permanente, Los Angeles, CA; 2Kaiser Permanente Los Angeles Medical Center, San Gabriel, CA; 3Kaiser Permanente, Santa Ana, CA; 4Kaiser Permanente Los Angeles, Pasadena, CA; 5Kaiser Los Angeles medical center, Los Angeles, CA; 6N/A, Westminster, CA

Purpose: To compare overall survival (OS) and disease-free survival (DFS) following percutaneous alcohol injection (PEI) and radiofrequency ablation (RFA) for the treatment of hepatocellular carcinoma.

Materials: This is a single-institution retrospective cohort study. Patients who underwent PEI or RFA between 2005 and 2009 for hepatocellular carcinoma without extrahepatic metastases were included in this analysis. Patient data was collected between the time of procedure to September 1, 2017. A chart review was performed for baseline characteristics, clinical success, complications, survival, disease recurrence, additional treatment, and transplant. Statistical analysis was performed using SPSS (IBM, New York).

Results: 126 patients are included in this analysis. 56 patients were treated with PEI and 70 patients with RFA. The RFA group had a significantly higher proportion of patients with Child Pugh A liver cirrhosis and tumors < 3 cm. Technical success was 95% and 98% for PEI and RFA, respectively. Complication rates for PEI and RFA were 11% and 9%, respectively. OS and DFS are summarized in Table 1. Patients in the RFA group had significantly higher OS at 2, 3, 4, and 5 years. Between 6 and 9 years there was no significant difference in OS between the two groups. Differences in DFS between PEI and RFA at all time points did not reach statistical significance. Analysis limited to patients with tumors < 3 cm demonstrated significantly higher OS in patients treated with RFA only at 1 and 5 years. The remaining time points showed no significant difference between the two groups. Similarly, analysis limited to patients with Child Pugh A liver cirrhosis showed significantly higher OS in the RFA group only at 3 and 4 years.

Conclusions: PEI and RFA have comparable DFS and long-term OS in patients with small hepatomas and good liver status based on Child-Pugh score.
Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>PEI OS (%)</th>
<th>RFA OS (%)</th>
<th>P</th>
<th>PEI DFS (%)</th>
<th>RFA DFS (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>79</td>
<td>87</td>
<td>0.3</td>
<td>52</td>
<td>57</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>71</td>
<td>0.01</td>
<td>29</td>
<td>41</td>
<td>0.2</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>56</td>
<td>0.01</td>
<td>29</td>
<td>29</td>
<td>0.6</td>
</tr>
<tr>
<td>4</td>
<td>31</td>
<td>53</td>
<td>0.01</td>
<td>23</td>
<td>27</td>
<td>0.3</td>
</tr>
<tr>
<td>5</td>
<td>23</td>
<td>43</td>
<td>0.01</td>
<td>21</td>
<td>23</td>
<td>0.4</td>
</tr>
<tr>
<td>6</td>
<td>23</td>
<td>36</td>
<td>0.07</td>
<td>21</td>
<td>20</td>
<td>0.5</td>
</tr>
<tr>
<td>7</td>
<td>23</td>
<td>34</td>
<td>0.1</td>
<td>21</td>
<td>20</td>
<td>0.6</td>
</tr>
<tr>
<td>8</td>
<td>23</td>
<td>31</td>
<td>0.2</td>
<td>21</td>
<td>17</td>
<td>0.8</td>
</tr>
<tr>
<td>9</td>
<td>20</td>
<td>28</td>
<td>0.1</td>
<td>20</td>
<td>16</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Ablation of colorectal liver metastasis: interaction of ablation margins and RAS mutation profiling on local tumor progression outcomes

B. Odisio¹, M. Calandrì², S. Yamashita³, C. Gazzera⁴, P. Fonio⁵, A. Veltri⁶, S. Bustreo⁷, R. Sheth⁶, S. Yevich⁸, J. Vauthey⁷, UT MD Anderson Cancer Center, Houston, TX; ²University of Turin, Città della Scienza, Turin, Turin; ³University of Turin, Città della Salute e della Scienza, Turin, Turin; ⁴MD Anderson Cancer Center, Houston, TX; ⁵University of Turin, Città della Scienza, Turin, Turin; ⁶University of Turin, Città della Salute e della Scienza, Houston, TX; ⁷University of Turin, Città della Scienza, Turin, Turin; ⁸University of Turin, San Luigi Gonzaga Hospita, Houston, TX; ⁹MD Anderson Cancer Center, Houston, TX; Assoc. Moazzam, Annandale, VA

Purpose: To investigate the impact of different minimal ablation margins on local tumor progression-free survival (LTPFS) rates according to RAS mutational status in patients with colorectal liver metastases (CLM).

Materials: This HIPAA compliant, IRB-approved two-institution retrospective study from 2005 to 2016 included 136 patients (91 male, median age 60 years) with 218 CLM (median size 1.8 cm [range 0.6-5.2]) successfully treated (primary efficacy rate: 100%) with radiofrequency or microwave ablation under computed tomography or ultrasound guidance. LTPFS for the ablated CLM was performed using the Kaplan–Meier method and evaluated with the log-rank test in respect RAS mutation profiling (wild-type vs. mutant type), and minimal ablation margin (≤10 mm vs. >10 mm). Minimal ablation margin was defined by the smallest ablation margin achieved on the three orthogonal planes on the first cross-sectional contrast-enhanced imaging study 4-6 weeks following ablation. Uni- and multivariate analyses were performed using Cox regression models.

Results: Median follow-up period was 25.1 months. Mutant RAS was detected in 39.7% (54/136) of the patients who had 80 ablated CLM. LTPFS rates of CLM with minimal ablation margin ≤10 mm were significantly worse than those with >10 mm in both subgroups of mutant RAS (3-year LTPFS, 29% [≤10 mm] vs 48% [>10 mm], respectively. P = 0.038) and wild-type RAS (3-year LTPFS, 70% [≤10 mm] vs 94% [>10 mm], respectively. P = 0.039). LTPFS rates of mutant RAS CLM were significantly worse than wild-type RAS in both subgroups of minimal ablation margin ≤10 mm (3-year LTPFS, 29% [mutant RAS] vs 70% [wild type RAS], P = 0.006). On multivariable analysis, predictors of worse LTPFS were minimal ablation margins ≤10 mm (HR: 2.17, 95% CI: 1.2-4.1, P = 0.007), CLM size ≥2 cm (HR: 1.80, 95% CI: 1.1-2.8, P = 0.017), and mutant RAS (HR: 2.85, 95% CI: 1.7-4.6, P<0.001).

Conclusions: Minimal ablation margin and RAS mutational status interact as independent predictors of LTPFS following CLM ablation. Achieving >10 mm minimal ablation margins in mutant RAS CLM could significantly improve LTPFS rates.

Radiofrequency ablation vs. cryoablation for localized hepatocellular carcinoma: a propensity matched population study using the Surveillance, Epidemiology, and End Results (SEER) database

C. Noda¹, A. Mills², J. Xu³, O. Akinwande⁴; ¹Washington University School of Medicine, St. Louis, MO; ²Mallinckrodt Institute of Radiology/Washington University, St. Louis, MO; ³Mallinckrodt Institute of Radiology, St. Louis, MO; ⁴Washington University School of Medicine in St. Louis, St. Louis, MO

Purpose: To compare the overall survival (OS) and Liver Cancer Specific Survival (LCSS) of localized (AICC I/II) Hepatocellular Carcinoma (HCC) patients treated with either Cryoablation (cryo) or Radiofrequency Ablation (RFA) screened from the Surveillance, Epidemiology, and End Results (SEER) database.

Materials: AJCC Stage I or II HCC patients from the SEER databased treated with Thermal Ablation techniques (cryoablation and RFA) between 2004-2013 were identified. A Kaplan-Meier, competing risk, and Cox regression were performed. Propensity score matching was also applied to account for different confounding demographic variables with the aforementioned statistical tests conducted for this new population. Background variables included in the propensity matching model included age, gender, race, cancer stage, tumor grade, tumor size, alpha fetoprotein (AFP) level, and fibrosis score.

Results: A total of 3239 patients (n = 3145 RFA) were included in the study. Before matching, the treatment groups were similar demographically with the exception of age, race and fibrosis score. The two treatment groups had similar overall survival (OS) (Cryo = 29 months [95% CI 21-40], RFA = 41 months [95% CI 39-43] p = 0.0657); however, RFA showed a significant survival advantage over cryoablation in liver cancer specific survival (LCSS) (HR = 1.634 p = 0.0004). Propensity matching produced 91 pairs that were similar in background variables. Again, there was similar OS between both groups (HR = 1.006 [95% CI: 0.688-1.469] p = 0.9768). However, this time there was no difference in LCSS between the groups (HR = 1.412 [95% CI: 0.933-2.137] p = .1023). Of note, overall survival was 34 months (95% CI: 22-46) in the RFA group and 34 months (95% CI: 22-44) in the cryo group. The final
Radiofrequency ablation of hepatic tumors: does heat sink affect the outcome?
N. Asvadi1, S. Seraj2, R. Arellano3; 1Berkshire Medical Center, Pittsfield, MA; 2San Joaquin General Hospital, Bakersfield, CA; 3Massachusetts General Hospital, Boston, MA

Purpose: To evaluate heat sink effect in computed tomography (CT)-Guided Radiofrequency ablation (RFA) of liver tumors.

Materials: A retrospective review was conducted of 315 patients who underwent CT-Guided RFA of primary and metastatic hepatic tumors between 2000 to 2011. Lesions were stratified as non-perivascular or perivascular tumors if they were less than 5 mm from a large intrahepatic vessel (>3 mm diameter). We assessed for residual tumor or tumor progression between the heat sink and non-heat sink tumors. Residual lesion and tumor progression were evaluated 1-month post-ablation then every 3 months for the first year and biannually thereafter by contrast-enhanced CT or magnetic resonance imaging (MRI) studies.

Results: 315 unique patients (M:F = 66.9:31.1%) with mean age of 61.4 years (SD 10.9) and 430 hepatic tumors (hepatocellular carcinoma = 263 and metastatic tumors = 167) were identified. One hundred and eighteen tumors (27.44%) were perivascular. Eighty-four of 430 tumors (19.5%) had residual lesions on follow-up CT scans within 3 months after radiofrequency ablation and 75 (17.4%) after 3 months of follow-up (tumor progression). There were more residual lesions in non-perivascular tumors within 3 months of RFA. However, the difference was only statistically significant in tumors less than 3 cm.

Conclusions: While the residual lesions were not significantly different between perivascular and non-perivascular tumors, except for tumors less than 3 cm, the residual lesions were significantly higher in non-perivascular lesions which truly challenges the clinical significance of so called “heat-sink” phenomenon.

<table>
<thead>
<tr>
<th>Table 1. Study of Heat Sink Effect and Residual/Recurrent Tumors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tumors</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Residual tumor</td>
</tr>
<tr>
<td>(within 3 m)</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Recurrent tumor</td>
</tr>
<tr>
<td>(&gt;3 m)</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

Scientific Session 41
Melange

Wednesday, March 21, 2018
3:00 PM–4:30 PM
Room: 410

Percutaneous revascularization for chronic mesenteric ischemia: does a residual pressure gradient affect clinical outcomes?
K. Jumaa1, S. Alshehri2, S. Kribs3; 1Western University Department of Medical Imaging, London, ON; 2University of Western Ontario, London, ON; 3N/A, London, ON

Purpose: Percutaneous revascularization has become a reliable option in the management of chronic mesenteric ischemia with much lower associated morbidity and mortality than surgical methods. Unlike peripheral arterial interventions, there are no quantitative endpoints for determining the success of mesenteric angioplasty. Complete angiographic patency or alleviation of an arterial pressure gradient across the stenosis is often not feasible. Furthermore, aggressive angioplasty is typically avoided as the consequences of a dissection or acute occlusion can be catastrophic. Our purpose is to examine whether a residual arterial pressure gradient after percutaneous revascularization affects clinical outcomes and patient symptomatology.

Materials: We present a single-institution retrospective observational study involving patients who underwent mesenteric revascularization between January 2009 and June 2017 for chronic mesenteric ischemia. Simultaneous intra-arterial pressures were obtained in the aorta and SMA or celiac trunk using an end-hole catheter with a pressure transducer. Patients who did not have post-angioplasty intra-arterial pressures recorded were excluded. Postprocedural vascular surgery clinic notes were reviewed to determine whether or not symptoms had improved.

Results: There were 20 revascularization procedures for which post-angioplasty arterial pressures are available: 14 SMA and 6 celiac trunk. Mean patient age was 69.3 years. All patients experienced post-prandial abdominal pain and most reported weight loss. All patients had at least one risk factor: hypertension, type 2 diabetes, coronary artery disease or stroke and smoking. Mean follow-up was 90.2 days (range, 33-218 days) Post-angioplasty gradients (systolic/mean) ranged from 4/0 - 65/28 mm Hg (mean 34.2/12.6 mm Hg). Minor complication rate was 8.6%. There were no deaths. Clinical improvement was reported in 100% of patients in follow-up. Three procedures were done prophylactically as the patients were asymptomatic but young with rising PSV on routine ultrasound.

Conclusions: Percutaneous mesenteric revascularization can improve symptoms of chronic mesenteric ischemia despite a residual arterial pressure gradient.
Women in interventional radiology: factors that influence women to pursue IR
D. Kumar1, L. Walker2, T. Bochnakova2, S. Mitchell3, J. Buehler2; 1University Hospitals Case Medical Center, Cleveland, OH; 2University Hospitals Cleveland Medical Center, Cleveland, OH; 3Johns Hopkins, Baltimore, MD

Purpose: Women are underrepresented in radiology and even more so in interventional radiology (IR) in the United States (27% and 8-12%, respectively) (R1-2). The goal of this survey is to evaluate the perspective of aspiring and practicing female radiologists nationally from all stages in their career and how this opinion has changed over time.

Materials: A survey was distributed nationally through social media with 148 female medical students, diagnostic radiology residents, IR fellows in addition to both diagnostic and IR practicing attending physicians. Survey questions included factors that influenced their decision to pursue or not to pursue a career in IR.

Results: Responses varied from all levels of training [attendings 93/148 (63%), fellows 16/148 (11%), residents 25/148 (17%), medical students 14/148 (9%)]. Of the 148 responders, 110 (74%) were not interested in pursuing IR. For those training or currently within the field of IR, 62/70 (89%) reported that having a female IR mentor would have added valuable career guidance. Additionally, 77/148 (52%) believe that having a greater presence of female IR attendings in their institutions would have changed their decision. Negative factors that discouraged women in pursuing the field include difficult work-life balance 78/148 (53%) and radiation risks during pregnancy 71/148 (48%). Other negative factors included male predominance 18/148 (12%) in the specialty, disinterest in patient contact 20/148 (14%) and procedures 40/148 (27%). Fifty-two of 148 (35%) of responders thought that there is equal support for men and women who are interested in IR during training.

Conclusions: This survey analysis of women at various training in their medical careers demonstrated the factors that contributed most to not pursuing IR included demanding lifestyle and radiation risk during pregnancy. In particular, women stated that educating trainees regarding minimal radiation exposures during IR procedures might increase interest in the field. More visibility of women who demonstrate healthy work-life balance in the IR field, strong female mentorship, and early exposure to IR during training may also attract more young female physicians to IR.

Efficacy and safety of CalliSpheres® drug-eluting beads transarterial chemoembolization in patients with secondary liver cancer: a preliminary result from CTILC study
X. Wu1, H. Hu1, S. Ying2, X. Guo3; 1Sir Run Run Shaw Hospital, Zhejiang University College of Medicine, Hangzhou, Zhejiang Province; 2The First Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang Province; 3Jinhua Central Hospital, Jinhua, Zhejiang Province

Purpose: To assess the treatment response, short-term overall survival (OS) and safety profiles of drug-eluting beads transarterial chemoembolization (DEB-TACE) in patients with secondary liver cancer.

Materials: 55 patients with secondary liver cancer underwent DEB-TACE were enrolled in this prospective cohort study. Treatment response was assessed by mRECIST. OS was calculated from the time of DEB-TACE operation until the date of death.

Results: The CR and ORR at 1-3 month post DEB-TACE were 12.7% and 67.3%. Mean OS was 383 d (95%CI: 360-406 d), and 6-month OS rate was 93.4% ± 3.7%. Subgroup analysis revealed previous cTACE treatment was correlated with worse ORR (P = 0.028), and it was a risk factor for ORR achievement (P = 0.021). As for liver function, the percentages of abnormal TP (P = 0.031), TBIL (P = 0.022), ALT (P = 0.002) and AST (P = 0.035) were increased at 1 week post DEB-TACE compared to baseline, while these four indexes returned to baseline (all P>0.05) at 1-3 month post DEB-TACE. As to safety profiles, 41 (66.1%), 28 (45.2%), 17 (27.4%), 8 (12.9%) and 6 (9.7%) cases had pain, vomiting, fever, nausea and other adverse events (AEs) respectively during DEB-TACE operation, while 26 (41.9%), 9 (14.5%), 8 (12.9%), 4 (6.5%), 1 (1.6%) and 2 (3.2%) cases had fever, vomiting, nausea, bone marrow toxicity and other AEs respectively at 1 month after DEB-TACE operation.

Conclusions: DEB-TACE was efficient and well tolerated in treating patients with secondary liver cancer.

Table 1. Clinical response of Patients and Nodules Posttreatment

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Patients (n = 55)</th>
<th>Nodules (n = 102)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR (n/%)</td>
<td>7 (12.7)</td>
<td>18 (17.6)</td>
</tr>
<tr>
<td>PR (n/%)</td>
<td>30 (54.5)</td>
<td>48 (47.1)</td>
</tr>
<tr>
<td>ORR (n/%)</td>
<td>37 (67.3)</td>
<td>66 (64.7)</td>
</tr>
<tr>
<td>SD (n/%)</td>
<td>13 (23.6)</td>
<td>27 (26.5)</td>
</tr>
<tr>
<td>PD (n/%)</td>
<td>5 (9.1)</td>
<td>9 (8.8)</td>
</tr>
</tbody>
</table>

Partial splenic artery embolization in 35 cancer patients
B. Kis1, M. Mills1, J. Smith1, H. Krzyston1, N. Parikh1, J. Choi1, R. Komroki1, R. Kim1; 1Moffitt Cancer Center, Tampa, FL

Purpose: Thrombocytopenia in cancer patients often contraindicates chemotherapy and/or surgery leading to suboptimal therapy and decreased overall survival. The purpose of our study was to determine safety and efficacy of partial splenic embolization to improve platelet count and to establish a standardized treatment plan to achieve ideal embolization endpoint and minimize post-procedural complications.

Materials: Medical records of 35 cancer patients who underwent 39 splenic artery embolizations with 300-500 μm Embospheres were analyzed. The target embolization endpoint was 50-70% splenic infarct. Celiac plexus block was performed following 25 procedures for pain control.

Results: The spleen volumes were 1337 ± 1038 mL. The embolization led to 59 ± 16% splenic infarct. One mL of microspheres resulted in 272 ± 107 mL splenic infarct in patients with chemotherapy- or portal hypertension-induced splenomegaly and
582 ± 3.45 mL infarct in patients with hematologic malignancies. The spleen volumes decreased by 40.5 ± 11% in 1 year. The platelet count increased from 63.9 ± 29.6 (mean ± SD) to peak platelet count of 248 ± 118 in 2-4 weeks after embolization. Patients with follow-up period of >1 year had the last platelet count of 174 ± 113 (n = 12). The most common complication was moderate/severe pain which occurred in 92% of patients without celiac block and in 20% of patients with celiac block. There was non-occlusive portal vein thrombus in 2 patients, pulmonary embolus in 1 patient, focal pancreatitis in 1 patient, and increased ascites and pleural effusion in 7 patients. Procedure-related 30-day mortality was 25% amongst patients with hematologic malignancies and 0% amongst patients with chemotherapy- or portal hypertension-induced splenomegaly. **Conclusions:** Partial splenic embolization is effective to correct thrombocytopenia in cancer patients and provides improved platelet count for long-term. It is a low risk procedure in patients with chemotherapy- or portal hypertension-induced splenomegaly, but has high mortality in hematologic malignancies. The post-procedural pain was significantly reduced by celiac plexus block. Based on our data the required amount of beads can be calculated to achieve target splenic infarct.

### Practice pattern change in the management of iatrogenic pseudoaneurysms at a tertiary care institution: experience in 164 patients

**Purpose:** To compare treatment outcomes of iatrogenic pseudoaneurysms (PSAs) before and after a practice change from cross-sectional radiology (CS) to interventional radiology (IR)-based management.

**Materials:** 164 patients with iatrogenic PSAs were identified from 2010 through 2016. 88 and 76 were identified before and after practice change, respectively. Patients included 83 (51%) men with mean age of 62 years (range, 1-93 years). PSAs resulted from procedures performed by interventional cardiology (n = 75, 46%), electrophysiology (n = 25, 15%), IR (n = 23, 14%), vascular surgery (VS) (n = 19, 12%), medicine (n = 7, 4%) neurosurgery (n = 5, 3%), cardiac surgery (n = 5, 3%), the intensive care unit (n = 5, 3%), & orthopedic surgery (n = 1, 1%). Prior to practice change, 92% of PSAs were treated by CS, 3% by VS, and 5% by IR; after practice change, 79% were treated by IR, 17% by CS and 4% by VS. Site, PSA, sheath size and closure device use during initial procedure, treating service, time from initial puncture to treatment, volume of thrombin, number of treatment sessions required, advanced techniques used, clinical success, and complications prior to and following practice change were recorded.

**Results:** No differences were observed in age, PSA volume, PSA neck size before or after practice change. More deep femoral artery PSAs were treated after practice change (p = 0.033); no difference in other access sites PSAs. Mean time from initial consult to treatment decreased significantly (45 to 15 hours, p = 0.015), with non-significant change in time to discharge. Mean time from consult to discharge also decreased, but not significantly (160 vs
124 hours). Advanced techniques were used in more patients (11% vs 2%, \( p = .028 \)) with increased successful first repair attempts (91% vs 87%, \( p = .46 \)). Advanced techniques were required in 13 cases after the practice change: angiography with balloon-assisted thrombin injection (5), open surgery (4), stent deployment (2), and coiling (1); advanced techniques were performed twice before change.

Conclusions: IR provides a shorter latency to treatment and enables successful treatment of more complex PSAs, as evidenced by both PSA location and proportion of cases requiring advanced techniques.

3:54 PM Abstract No. 405

GPX by Fluidx Medical Technology: a new proprietary in situ setting embolic agent that combines the benefits of coils, gel beads, and liquid embolics
J. Jones\(^1\), J. Karz\(^1\); \(^1\)University of Utah, Salt Lake City, UT

Purpose: A novel embolization agent was developed (GPX), which combines advantages of particle, coil, and liquid embolic agents but minimizes their disadvantages. This approach was inspired by the adhesive of marine sandcastle worms. The natural biomaterial is packaged and stored as sets of oppositely charged polyelectrolytes (PEs) which are condensed into complex fluids (coacervates). Within seconds of secretion, it hardens into a solid viscoelastic gel. The transition in morphology is largely driven by changes in ionic composition and concentration when the coacervate is exposed to seawater. The in situ setting GPX embolic was designed to mimic the condensed polyelectrolyte composition and environmentally triggered setting mechanism of the natural sandcastle glue, thus avoiding polymerizing components and precipitation from organic solvents.

Materials: Using injection pressure measurements, GPX was formulated for injectability through microcatheters by adjusting NaCl concentration. Flow and oscillatory rheology were used to quantify gel properties in both initial and final forms. Gamma sterilization, hemolysis, cytotoxicity, and catheter entrapment risk were assessed. Acute embolization of rabbit and pig kidneys were performed. Stability of occlusion and histological response (1 month) were evaluated in rabbit ears. The material was non-cytotoxic, non-hemolytic, and stable at 1 month with no migration. Gamma sterilization can be performed. In acute in vivo experiments, it was deliverable with no catheter reflux and demonstrated complete devascularization without crossing into venous circulation. Occlusions of rabbit auricular arteries remained stable at 1 month with no migration. Gamma sterilization can be performed on GPX without affecting material properties, and minimal force was required to remove a catheter from the solidified embolic. The material was non-cytotoxic, non-hemolytic, and incited a benign tissue response.

Conclusions: Because of its water-borne composition, ease-of-use, and biomimetic design, GPX represents a promising new agent for a variety of embolization scenarios.

4:03 PM Abstract No. 406

Arterial embolization using novel shear-thinning biomaterials in rats
H. Albadawi\(^1\), A. Witting\(^1\), P. Hangge\(^1\), Y. Pershad\(^1\), P. Salmon\(^2\), A. Khademhosseini\(^3\), R. Oklu\(^1\), J. Jones\(^1\); 1University of Utah, Salt Lake City, UT; 2University of California, San Francisco, San Francisco, CA

Purpose: Our laboratory has developed a novel class of hemo-static shear-thinning biomaterials (STB) with unique properties. Following injection into femoral arteries, we examined its long-term histologic changes, biocompatibility, assessed for breakdown/fragmentation, and performed extensive micro-CT imaging evaluation of the injected biomaterial at 10-micron resolution.

Materials: Rats underwent unilateral femoral artery (FA) injection with STB containing lohexol between the proximal profunda and distal bifurcation. FA occlusion was confirmed with murine ultrasound (US) Doppler Vivo system, and hind limb perfusion was measured using laser speckle contrast analysis. Limit function was evaluated by the Tarlov scale. FA tissue was harvested for extensive histologic and micro-computed tomography (micro-CT) studies at 3, 7, and 21 days. Micro-CT images of fixed FA tissues were acquired using SkyScan-1275 scanner. NR Recon and CTAn software were used to reconstruct and obtain density threshold adjusted volume of interest (VOI) for morphometric analysis.

Results: STB injection did not result in distal ischemia or change in ambulation function (Tarlov score = 6). STB injection caused 50% decrease in hind limb perfusion that persisted 21 days after surgery (\( p = 0.0001 \)); however, digit perfusion was preserved. US Doppler confirmed continued occlusion of the FA. Micro-CT morphometric VOI analysis revealed an increase in surface to volume ratio (\( p = 0.006 \)), surface convexity index (\( p = 0.002 \)), and structure model index (\( p = 0.037 \)), while fractal dimension was significantly decreased (\( p = 0.041 \)) at 21 days compared to 3 days, indicating continuous STB remodeling. Histology revealed ongoing STB degradation and intraluminal remodeling with fibrous tissue formation and limited cellular infiltration in the arterial wall.

Conclusions: STB arterial injection led to persistent focal embolization of FA without migration or fragmentation; there were no distal limb perfusion deficits. Extensive Micro-CT, ultrasound and histologic studies revealed STB biocompatibility and biodegradation consistent with expected safety profile. This study suggests STB can be used as a permanent or potentially reversible biocompatible liquid embolic agent.

4:12 PM Abstract No. 407

Preliminary Development of a Silk-elastinlike protein polymer based embolic for cerebral aneurysms
M. Jensen\(^1\), K. Isaacson\(^1\), D. Steinhauff\(^1\), B. Green\(^1\), M. Correa\(^1\), J. Cappello\(^1\), L. Eisenmenger\(^2\), E. Huo\(^2\), H. Ghandehari\(^1\), J. Jones\(^1\); 1University of Utah, Salt Lake City, UT; 2University of California, San Francisco, San Francisco, CA
**Purpose:** Novel embolic therapies are needed to improve cerebral aneurysm (CA) healing and reduce the risk of recanalization. Embolization and flow diversion are the standards of care to prevent intracranial hemorrhage in high-risk patients. However, metal embolization coils and flow diversion devices require larger catheters for delivery, require anticoagulation, cause artifacts on follow-up imaging via MRI or CT, induce thrombus, and can undergo recanalization. Liquid embolics have the potential to completely fill an aneurysm, but current liquid embolics are challenging to use due to their high viscosity, limited selection of compatible catheters, and dependence on potentially toxic organic solvents. Next-generation liquid embolics will have the advantages of not using potentially toxic organic solvents, low viscosity to allow flow through small diameter microcatheters, and have the capacity to carry various classes of therapeutics, while providing durable embolization of the target lumen. We hypothesize that silk-elastinlike protein polymers can be designed to meet these requirements. The objective of this work is to evaluate the basic physicochemical properties of silk-elastinlike protein polymers (SELP) for use in embolizing cerebral aneurysms while simultaneously delivering localized therapy.

**Materials:** We produced SELP 815K, which contains 8 silklike motifs, 15 elastinlike motifs, and one lysine-substituted elastinlike motif per monomer repeat, from a recombinant plasmid. The SELP 815K was purified from the crude biomass and sheared as a 12% (wt%) in phosphate buffered saline as described previously. This was evaluated using rheometry and in a 3D patient-derived model of a carotid artery aneurysm.

**Results:** SELP had injectable viscosity of $67 \pm 4$ cP at 23 °C, easily injectable through a 2.4 Fr microcatheter at a rate of 0.5 mL, and achieved a peak storage modulus of greater than 105 Pa within 3 hours. It was able to successfully embolize the model aneurysm.

**Conclusions:** SELP 815K was successfully employed as an embolic for treating a simulated cerebral aneurysm. The solution was able to be injected through a microcatheter and achieve durable gelation in a model aneurysm.

---

**Table 1. Summary of Study Design and Results by Angiography**

<table>
<thead>
<tr>
<th>Aneurysm Type</th>
<th>Maturation Period (Days)</th>
<th>Mean Aneurysm Dome Height (mm)</th>
<th>Mean Aneurysm Dome Depth (mm)</th>
<th>Mean Aneurysm Dome Height/Neck Width Ratio</th>
<th>% Acute Occlusion</th>
<th>% Chronic Occlusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal Bifurcation</td>
<td>22-693</td>
<td>14.6</td>
<td>8.7</td>
<td>3.9</td>
<td>95</td>
<td>27-85</td>
</tr>
<tr>
<td>Sidewall</td>
<td>471</td>
<td>8.4</td>
<td>6.4</td>
<td>1.8</td>
<td>100</td>
<td>63</td>
</tr>
</tbody>
</table>

**Purpose:** Metactive Medical’s Ballstent Microcatheter was used along with coils to treat terminal bifurcation and sidewall aneurysms in canines.

**Materials:** Seven crossbreed hounds (20.0 - 23.7 kg) each underwent surgical procedures to create venous pouch aneurysms using published methods *(Table 1).* In each of six dogs, a single narrow or wide-neck aneurysm was constructed by joining a segment of external jugular vein (EJV) onto a newly created carotid artery terminal bifurcation. In one dog, wide-neck sidewall aneurysms were created on both the right and left carotid artery using segments of EJV. At the end of the maturation period, a 6 mm or 8 mm Ballstent was used to occlude each aneurysm neck and custom nitinol coils (Metactive Medical) and/or Barricade coils (Blockade Medical, LLC) were passed through the expanded Ballstent and placed into the aneurysm sac behind it to promote aneurysm thrombosis and to hold the expanded Ballstent in place across the aneurysm neck. In two narrow-neck terminal bifurcation aneurysms, an additional Barricade coil was placed from a parent artery approach to occlude a residual neck segment, in one instance immediately after Ballstent detachment and in the other 29 days later. Angiography was performed immediately before and after treatment and immediate posttreatment% aneurysm occlusion was estimated. Terminal angiography was performed 27 to 85 days after initial treatment, % aneurysm occlusion was estimated, and aneurysms were collected for histology.

**Results:** For terminal bifurcation aneurysms (n = 6), both acute and chronic occlusion were nearly complete while for sidewall aneurysms (n = 2) both acute and chronic occlusion were complete *(Table 1).* Histology was available for four terminal bifurcation aneurysms, demonstrating mean chronic occlusion of 98% and a well-organized, mature, and fully endothelialized neointima covering all or nearly all of the aneurysm neck.

**Conclusions:** Treatment of narrow and wide-neck bifurcation and wide-neck sidewall aneurysms with the Ballstent and coils results in complete or nearly complete aneurysm occlusion and rapid endothelialization of the aneurysm neck.
Efficacy of false lumen embolization as a complementary treatment of chronic progressive dissection

X. Kos¹, P. Revel-Mouroz², F. Mokrane², O. Meyrignac², H. Bertoni³, H. Rousseau²; ¹Cardiac and Medical Clinic of Aressy, Pau, France; ²Rangueil University Hospital Center, Toulouse, France; ³University Hospital Center, Buenos Aires, Argentina

Purpose: To appreciate the efficacy of the false lumen embolization as a complementary treatment of chronic progressive aortic dissection in order to minimize aneurysmal increasing by occluding the dissection entrance.

Materials: From January 2005 to September 2016, a retrospective monocentric study has been carried out. Clinical and radiological data, including the total, true and false lumen diameters have been recorded at 5 different levels. The stage of false lumen thrombosis has been appreciated by CT-scanner before and after treatment.

Results: 57 procedures were realized on 35 patients (29 males, 82.9%), 33 procedures in type B dissection. The medium follow-up was 1.01 year, IQR (0.24,2.18). In 37 procedures (64.9%), the total aortic diameter has been stabilized, showing an improvement or expanding less than 5 mm. An improvement of over 10% of the true lumen compared to total aortic diameter has been reported in 37 procedures (64.9%). The complete thrombosis of the false lumen (stage II and II of Parsa and al. classification) was observed in 29 cases (50.9%) after treatment, compared to 2 cases (3.5%) before treatment. The procedural mortality was 2/35 (5.7%) and global mortality 4/35 (50.9%) after treatment, compared to 2 cases (3.5%) before treatment.

Conclusions: False lumen embolization as a complementary treatment of chronic aortic dissection leads to a significant true lumen expanding as well as false lumen thrombosis. Both factors contribute to slow aneurysmal progression.

Transradial approach for the management of ruptured mesenteric artery aneurysms

D. Kestenbaum¹, D. Shilo¹, R. Lookstein¹, A. Fischman¹, E. Kim¹, F. Nowakowski¹, M. Ranade¹, V. Bishay¹, R. Patel¹; ¹Icahn School of Medicine at Mount Sinai Hospital, New York, NY

Purpose: Rupture of aneurysms involving the mesenteric arteries and their proximal branches is a rare but potentially life-threatening event. We report our experience with transradial technique and clinical outcomes for endovascular treatment of ruptured mesenteric aneurysms.

Materials: This review was exempt from institutional IRB approval. A retrospective review was performed of all cases performed at our institution from 2014 to 2017. Basic patient demographic information, presenting symptoms, procedural details, subsequent admission data, and clinical/imaging follow-up was recorded. Three patients (1M/2F; mean age 68) with mesenteric artery aneurysm rupture treated endovascularly were identified at our institution. The cases were as follows: A 61 y/o Male presenting with severe abdominal pain who was found to have both a superior pancreaticoduodenal hemorrhage which was embolized with histoacryl glue and a concurrent gastroduodenal hemorrhage which was embolized with coils, a 76-year-old Female presenting with abdominal pain who was found to have a SMA aneurysm which was embolized with glue, and a 68-year-old woman presenting with left lower quadrant pain and rectal bleeding who was found to have a ruptured IPDA aneurysm which was embolized with coils.
Results: All cases were performed using a transradial approach. Immediate post-embolization technical success, defined as absence of active bleeding on intraoperative angiography, was 100%. None of the patients rebled over a mean clinical follow-up time of 850 days. No patients required subsequent intervention. One patient had a subsequent admission for PE and another patient had an admission for acute cholecystitis. The average time to discharge following the initial intervention was 5 days. All patients are still alive.

Conclusions: Radial access is safe and effective in the management of mesenteric aneurysm rupture.

Biphasic contrast CT for endoleak identification
D. Olakunbi$^1$, A. Alsaﬁ$^2$, W. Hakim$^3$, M. Jenkins$^3$, E. Kashef$^4$,$^5$,$^6$,$^7$Imperial College Healthcare NHS, London, United Kingdom; $^2$Imperial College Healthcare NHS, London, United Kingdom

Purpose: Endoleaks are the Achilles heel of aortic intervention as these can lead to sac expansion and potential rupture if untreated. The mainstay of follow-up is CT angiography (CTA). We set out to compare the image quality of conventional CTA with biphasic injection CT in endoleak surveillance post aortic intervention.

Materials: 42 consecutive patients who underwent aortic stenting and had surveillance CTA were subsequently followed up with a biphasic CT with a single acquisition at 70 s. Only those without further intervention in between studies were included. Images were analyzed for arterial, venous and parenchymal attenuation. Two separate semi-quantitative 5-point scoring systems were used to assess the arterial and parenchymal image quality. All studies were double reported and the presence of endoleaks compared.

Results: Although the mean arterial enhancement was higher in the CTA group, overall arterial image quality was comparable ($r = 0.849$). One type II endoleak was only seen on the biphasic study, while another type II was only seen on CTA.

Conclusions: Comparable arterial image quality and endoleak detection can be achieved using a biphasic intravenous contrast injection CT protocol while allowing for solid abdominal organ assessment.

Peripheral atherectomy in Trans-Atlantic Inter-society Consensus (TASC) type C and D femoropopliteal lesions in chronic limb ischemia
V. Ukirde$^1$, A. Bansal$^2$; 1Lokmanya Tilak Municipal Medical College, Navi Mumbai, Maharashtra; 2Lokmanya Tilak Municipal Medical College & General Hospital, Mumbai, Maharashtra

Purpose: To evaluate the efficacy of peripheral atherectomy device in TASC type C and D femoropopliteal lesions.

Materials: In a period of 14 months (December 2015 to January 2017), all patients with complaints of chronic limb ischemia were evaluated. A detailed clinical and laboratory evaluation, doppler scan with lower limb CT angiography was performed, to determine TASC lesion type for femoropopliteal lesions. Patients falling in TASC C and D category were included in the study. Written informed consent was obtained. All the 11 patients were males and mean age was 56 years. 2 or more of risk factors (hypertension, diabetes, smoking and hyperlipidemia) were present in all patients.

Clinically, all patients fell in Rutherford IV to VI category (category III-1, IV-2, V-1, VII-7). 2 patients had ABI beyond 1.2, suggestive of heavily calcified vessels. Femoral access was taken and occlusion was crossed using hydrophilic 0.035” guide-wire (Terumo) in 8 patients and using 0.014” wire (Nitrex, Medtronic) in 3 patients. The 0.035” wire was exchanged with 0.014” wire and Directional Atherectomy device (Turbohawk, Medtronic) was then used. A distal embolic protection device was not used. Post-atherectomy angiogram was taken, followed by DCB angioplasty...
Arterial interventions using a novel balloon catheter

L. Leon1, A. Kokkosis2, A. Gasparis3, N. Labropoulos2,
1Agave Surgical Associates, Tucson, AZ; 2Stony Brook University Medical Center, Stony Brook, NY; 3Stony Brook Medicine, Melville, NY

Purpose: Imaging during arterial angioplasty requires contrast injection from a sheath located some distance from the site of intervention or by exchanging for a diagnostic catheter. Injections through a sheath has limitations, including contrast volume, timing of injection and radiation exposure. Exchange for a diagnostic catheter may lead to loosing wire access and is associated with increased procedural steps. A novel balloon catheter with a dedicated injection port can overcome the above concerns and improve imaging during percutaneous angioplasty (PTA).

Materials: The aim of this study was to evaluate the use of a novel balloon during arterial interventions. Consecutive patients undergoing femoral-popliteal procedures were collected prospectively. Procedures were performed by a single vascular surgeon in an outpatient angiography suite. Demographic data, type of intervention, location of disease, amount of contrast used, radiation time and complications were collected.

Results: Femoral-popliteal interventions were performed in 10 patients with an average age of 76. Indications for treatment was rest pain in 5 and tissue loss in 5. All patients were Rutherford’s Class 4 or higher with an average lesion length was 190 mm. All underwent athereectomy and PTA with a 5- or 6-mm balloon. Seven patients required stenting. The average contrast used was 47cc and the average radiation time was 23 min. There were no peri-procedural complications with an average follow-up of 1 month. Rest pain resolved in all patients and all interventions were patent on duplex ultrasound.

Conclusions: This novel PTA balloon catheter, primarily used for dialysis access procedures, is available in 5- to 8-mm diameters, 4-cm length and the shaft in 75-cm length. While current sizes can be used for some arterial lesions, some modification in the device are necessary for treating a wide range of arterial lesions. The technology has advantages of reduction in contrast use, improvement in image quality, decrease in radiation exposure and reduction in exchanges during peripheral PTA.

Superselective cervicovaginal branch vessel small particle embolization of a bleeding cervical fibroid: cone-beam CT and MR correlation

J. DeMeritt1, A. Wattamwar1, A. Albert1, R. Levat1, T. Chervoni-Knapp1, E. Wajswol2, Hackensack University Medical Center, Hackensack, NJ; 2Rutgers NJMS, Newark, NJ

Purpose: Symptomatic cervical fibroids have proven difficult to treat conservatively by uterine artery embolization (UAE) or myomectomy. Cervical fibroids represent about 5% of all myomas. UAE has had limited success in treating cervical fibroids probably secondary to inherent hypovascularity, the use of relatively large particles, and nonselective embolization. Complete necrosis of cervical fibroids following UAE has only been reported in approximately 20% of patients, even using small particle PVA. Cervical myomectomy is challenging due to limited operative field access and contact with vital structures such as the bladder, rectum, and ureters.

Materials: A 37-year-old female with a long history of menorrhagia presented with persistent vaginal bleeding, dizziness, and anemia requiring a blood transfusion. The patient was diagnosed with an isolated cervical fibroid measuring 3.6 x 3.3 x 4.4 cm on MRI. The patient desired to maintain future fertility and underwent bilateral selective cervicovaginal branch vessel embolization with 100- to 300-micron Embospheres until stasis. Intra-arterial verapamil was administered to enhance particle penetration. Cone-beam CT was used to exclude non-target vaginal and uterine body/fundus enhancement prior to embolization. The patient was followed for bleeding.

Results: The patient’s vaginal bleeding stopped immediately after the embolization and was discharged the following day without complication. Normal menses resumed. No vaginal dryness or change in sexual function including the ability to achieve orgasm. MRI at 3 months post UAE demonstrated complete necrosis with a 91% fibroid volume reduction. The patient became pregnant in close proximity to the MRI, delivering a 6 lb. 9.6 oz male via spontaneous vaginal delivery at 38 1/7 weeks without complication. No cervical incompetence reported. MRI at 14 months post UAE showed a 96% volume reduction.

Conclusions: Small particle selective embolization of the cervicovaginal arteries with vasodilator augmentation was a safe and effective treatment for a bleeding cervical fibroid resulting in cessation of menometorrhagia, no change in sexual function, and preservation of fertility with a final fibroid volume reduction of 96%.

Uterine fibroid embolization followed by planned hysteroscopic resection: a proposed treatment paradigm

J. Smirniotopoulos1, J. Cormran-Homonoff2, T. Fenster1, Y. Havryliuk1, B. Shaktman1, M. Schiffman2, 1New York Presbyterian Hospital/Weill Cornell Medicine, New York, NY; 2N/A, New York, NY; 3Weill Cornell, NY, NY

Purpose: Uterine fibroids are the most common benign tumor of the female reproductive tract. Although UAE has become an effective and safe treatment option, there are few data on the use of UAE followed by hysteroscopic resection. We present a case report of a 37 year old female who presented with heavy menstrual bleeding and polymenorrhea despite medical therapy. UAE was performed using the Raypax device (Medtronic). Co-existing tibial disease noted in 9 patients and co-existing iliac disease was treated. Technical success was considered if residual stenosis was less than 30%. Patients were evaluated on follow-up at 1, 3 and 6 months for symptomatic relief, limb salvage and for ABI.

Results: Postprocedure, increase in ABI was noted in the 9 patients with ABI between 0.2 to 0.8. In the 5 patients presenting with digital gangrene, level of amputation was confined to digits and thus preventing further progression of gangrene. Satisfactory wound healing was noted in all the 7 patients in Rutherford category VI. 1 patient with rest-pain had persistence of symptoms, despite persistently improved ABI and no residual stenosis on follow-up angiogram.

Conclusions: Combination of atherectomy device with DCB, provides significant limb salvage results for TASC C and D femoropopliteal lesions.
**Purpose:** To evaluate the effectiveness of uterine fibroid embolization (UFE) followed by planned hysteroscopic resection in the treatment of large, symptomatic submucosal fibroids.

**Materials:** This retrospective study was approved by the Institutional Review Board at the authors’ institution. Thirty patients with submucosal fibroids underwent UFE performed by two different interventional radiologists followed by hysteroscopic resection performed by three different gynecologists. Each patient received a pre-embolization pelvic MRI and 19 patients received a post-embolization, pre-resection pelvic MRI. Pre-embolization fibroid size, percentage of target fibroid size at time of resection, estimated blood loss during resection, and pathologic description of the surgically resected fibroid, pre- and postoperative uterine size were evaluated, and patient symptoms were assessed by the gynecologist in follow-up appointments.

**Results:** From August 2011 to August 2016, thirty patients with symptomatic leiomyomas were treated with bilateral UFE followed by hysteroscopic resection (median days from embolization to resection 35 days, range 21-91 days). The average uterine volume on pre-embolization MRI was 526.7 cm³, and all patients had a dominant submucosal fibroid with a maximum diameter of 4.4-6.0 cm. Post-embolization MRI demonstrated partial to complete necrosis of the target fibroid. In all cases, the fibroids were completely surgically resected in a single session with average blood loss less than 20 mL, and without complications. Following resection, all patients reported complete resolution of their pretreatment menorrhagia and pain at a median follow-up 118 days, mean 140 days.

**Conclusions:** In patients with large symptomatic submucosal fibroids, UFE followed by planned hysteroscopic resection represents a potential treatment paradigm combining minimally invasive techniques with surgery to mitigate the most serious complications of either procedure performed in isolation.

---

**Abstract No. 418**

**When should embolization for osseous pelvic trauma be considered? An exploratory analysis to identify predicting factors for embolization compared to noninterventional methods.**

**B. Bones**, S. Burner, E. White, D. Smith, J. Hoth, P. Miller, K. Dickey; Wake Forest University School of Medicine/Baptist Medical Center, Winston Salem, NC; Wake Forest University School of Medicine, Winston Salem, NC

**Purpose:** Protocoled management of trauma improves outcomes in the “golden hour,” however they need to be continuously reviewed as diagnostic technology improves. As the standard resolution of an axial CT has decreased from 5 mm to 0.63 mm, and thus less volume averaging, “contrast blush” or “extravasation” on newer scanners may not equate to its historical severity. The goal of our study is to identify factors, from both initial clinical presentation and CT interpretation on contemporaneous technology, that predict the need for embolization after osseous pelvic injury.

**Materials:** We conducted a review of pelvic injuries at our institution from 2014 to 2015. Cases were excluded if angiography was performed for another reason (e.g., splenic trauma), incomplete data, or death on day of injury. Factors such as age, injury severity scale, blood pressure, and gender were obtained from the trauma registry. Other factors such as fracture and joint injury, extravasation and hematoma were coded from the original trauma registry. Other factors such as fracture and joint injury, and cementoplasty of a lumbar vertebra (n = 1). Arterial interventions included transarterial embolization of renal (n = 6), hepatic (n = 2), and pelvic vessels (n = 2), diagnostic arteriography (n = 4), and embolization of arteriovenous malformations (n = 1). Posterior approach percutaneous interventions included retroperitoneal (n = 5) and pelvic (n = 1) mass biopsies, percutaneous nephrostomy placement (n = 2), cryoablation of pelvic (n = 2) and renal (n = 1) tumors, sclerotherapy of arteriovenous malformations (n = 2), nephroscopic foreign body retrieval (n = 2), microwave ablation of a renal tumor (n = 1), intracavitary antifungal injection into pulmonary mycetoma (n = 1), and radiofrequency ablation and cementoplasty of a lumbar vertebra (n = 1). Arterial intervention technical success was 100% (15/15). Posterior approach intervention-technical success was 100% (15/15). All biopsies included transarterial embolization of renal (n = 2), nephroscopic foreign body retrieval (n = 2), microwave ablation of a renal tumor (n = 1), intracavitary antifungal injection into pulmonary mycetoma (n = 1), and radiofrequency ablation and cementoplasty of a lumbar vertebra (n = 1). Arterial intervention technical success was 100% (15/15). Posterior approach intervention-technical success was 100% (15/15). All biopsies...
were diagnostic (6/6). No minor or major access-site complications occurred related to PTRA.

Conclusions: PTRA is a technically successful and safe method for performing combined endovascular and percutaneous posterior-approach interventions without the need for repositioning. Additional studies are warranted.

**Abstract No. 420**

The evolution of splenic artery aneurysm endovascular transcatheter embolization: a single-center comparison of the first 50 aneurysms versus the most recent 50 aneurysms

J. Loewenstein, S. Baral, R. Patel, E. Kim; F. Nowakowski, R. Lookstein, A. Fischman; Icahn School of Medicine at Mount Sinai, New York, NY; Mount Sinai Hospital, New York, NY; Mount Sinai Medical Center, New York, NY

Purpose: The present study aimed to compare procedural outcomes and costs of splenic artery aneurysm (SAA) embolization in our early experience with that of more recent years.

Materials: 100 SAA treated in 86 patients with transcatheter coil embolization were reviewed from 2002-2017. Patient and SAA characteristics (type, size), procedural details (femoral or radial approach, inflation-adjusted direct cost of embolization), and postprocedural outcomes (technical success, adverse events, length of hospital stay) were compared between the earlier (50 SAA in 41 patients, 2002-2010) and later (50 SAA in 45 patients, 2011-2017) treatment groups.

Results: Compared to the earlier treatment group, later SAA treatments did not differ by median age (56 vs. 52 years), sex (73.3% vs. 61.0% female), aneurysm size (2.3 vs. 2.5 cm), or type (98.0% vs. 90.0% true aneurysm, 2.0% vs. 10.0% pseudoaneurysm, p’s > 0.2). The later SAA treatments cost more to perform (inflation-adjusted median = $10,856 vs. $8,822, p = 0.048), used the radial approach more often (55.6% vs. 0%, p = 0.001), required shorter postprocedural hospital stays (mean = 0.87 vs. 1.02 days, p = 0.013), and needed less frequent reintervention (0% vs. 9.8%, p = 0.048). Fewer minor adverse events, such as major splenic infarction, non-target embolization, and access-site hematoma, were found in the later group (15.6% vs. 29.3% SIR Class A and 0% vs. 4.9% Class B) at a trend level (p = 0.066). No differences were found for primary or secondary technical success (100% vs. 100% and 89.4% vs. 97.9%, p = 0.20).

Conclusions: SAA embolizations in more recent years had higher post-procedural outcomes (technical success, adverse events, length of hospital stay) were compared between the earlier (50 SAA in 41 patients, 2002-2010) and later (50 SAA in 45 patients, 2011-2017) treatment groups.

**Abstract No. 421**

Role of technetium-99m lung shunt fraction studies for the detection of primary recanalization after pulmonary avm embolization in patients with hereditary hemorrhagic telangiectasia (HHT)

M. Haddad, E. Bendel, M. Bold, A. Parvinian, W. Harmson, I. McPhail, A. Stockland, V. Iyer; Mayo Clinic, Rochester, MN; St Marys Hospital, Rochester, MN; N/A, Rochester, MN

Purpose: To determine whether HHT genotype influences recanalization rates after pAVM embolization.

Materials: We retrospectively identified all patients with HHT undergoing embolization for pulmonary AVMs between January 2000 and August 2017. Only pulmonary AVMs with no prior treatment and patients with both clinical and imaging follow-up were included. Imaging follow-up included a pre- and postprocedure technetium-99m lung shunt fraction study and another imaging study that could evaluate for recanalization such as a contrast-enhanced CT chest or pulmonary angiogram.

Results: Ninety-two pulmonary AVMs (pAVMs) met the above criteria and were embolized with coils or plugs in 27 patients with HHT in 35 separate cases. The patients consisted of 9 males (33%) and 18 females (66%) with an average age of 56 (range, 26-81). Treatment included Nester coils only (n = 35, 38%), Tornado only (n = 20, 22%), combination of Nester and Tornado coils (n = 31, 34%), amplatzor plug (n = 3, 3%), and other coils (Hilal-Silver and Ruby) (n = 3, 3%). Technical success was achieved in all cases. Mean follow-up was 5.2 years (range, 0.1-12.2). There were 8 (8.7%) pAVMs that demonstrated primary recanalization as determined by a contrast-enhanced CT chest or pulmonary angiogram. The shunt fraction increased in the recanalization group by 2.2% (range, -3.4 to 9.1) versus a reduction of 3.1% (range, -19.1 to -9.1) in the non-recanalization group. Statistical analysis using univariate analysis demonstrated significant difference (p = 0.0195) between the two groups.

Conclusions: There was a significant shunt fraction difference between the treated pAVMs that recanalized and those with durable treatment, specifically the recanalized group had a mean increase in their post-procedural pulmonary shunt. As such, technetium-99m lung shunt fraction studies may be useful in surveillance of embolized pAVMs in patients with HHT. Furthermore, technetium-99m lung shunt fraction studies may serve as a viable option for follow-up in patients with contraindications to a CT chest with iodinated contrast or a pulmonary angiogram.

**Abstract No. 422**

Genetic mutational status and risk for recanalization in embolized pulmonary AVMs (pAVMs) in patients with hereditary hemorrhagic telangiectasia (HHT)

M. Haddad, E. Bendel, A. Parvinian, W. Harmson, I. McPhail, A. Stockland, V. Iyer, S. Misra; Mayo Clinic, Rochester, MN; St Marys Hospital, Rochester, MN; N/A, Rochester, MN

Purpose: To determine whether HHT genotype influences recanalization rates after pAVM embolization.

Materials: We retrospectively identified all patients with HHT undergoing embolization for pulmonary AVMs between January 2000 and August 2017. Only patients who had undergone genetic testing and had both clinical and radiological follow-up were included in this study.

Results: Twenty-nine HHT patients (16 male) with a median age of 52 years (11-90) were included of whom 20 patients had ENG
Comparison of Blockstent™ microcatheter with AMPLATZER™ vascular plugs and Cook Nester® embolization coils in canine model of acute and chronic arterial occlusion

K. Murphy1, L. Clausen2, D. Groth3, R. Larrabee2, H. Loree4, J. Richardson4, S. Rousselle5, D. Sidhu6, L. Szenay5, F. Franano1, University of Toronto, Toronto, ONT; ‡Surpass, Inc., Osceola, WI; ‡Dale Groth Preclinical Consulting, LLC, Forest Lake, MN; ‡Metactive Medical, Inc., Lowell, MA; ‡Alizee Pathology, LLC, Thurmont, MD; ‡CIRTEC Medical, LLC, Los Gatos, CA; ‡Metactive Medical, Inc., Fairway, KS

Purpose: Prototypes of Metactive Medical’s Blockstent™ Microcatheter were evaluated in a canine internal thoracic artery (ITA) and axillary artery (AA) acute and chronic occlusion model and compared with the AMPLATZER™ Vascular Plug II (AVP2), AMPLATZER™ Vascular Plug 4 (AVP4), and Cook Nester® Embolization Coils (coils).

Materials: Eleven crossbred hounds (18.0 - 23.3 kg) each received bilateral implants in either the ITA (4 mm Blockstent, 4 mm AVP4, or 3 mm coils) or AA (6 mm Blockstent or 6 mm AVP2). Angiography was performed prior to, immediately after, and 4 weeks after device implantation. Following sacrifice at 4 weeks, a limited necropsy was performed and treated vessel segments were collected for histology.

Results: The Blockstent provided immediate and complete acute occlusion in all cases (n = 8). The AVP2, AVP4, and coils failed to provide immediate and complete acute occlusion in all cases (n = 4 for each). By angiography, the Blockstent provided complete chronic occlusion at 4 weeks in 7 of 8 cases. By histology the Blockstent treated vessels showed a mean occlusion of 98%. By angiography, the AVP2, AVP4, and coils provided complete chronic occlusion in 0 of 12 cases, and by histology the treated vessel segments showed a mean occlusion of 52%, 59%, and 81%, respectively. The Blockstent Microcatheter demonstrated superior deliverability and fluoroscopic conspicuity when compared with AVP2 and AVP4, and more precise placement when compared with coils. The 6 mm Blockstents demonstrated some extrinsic compression in the AA at 4 weeks. None of the devices showed chronic migration. Observations of vessel wall injury and inflammation by histology were similar among all of the devices.

Conclusions: The Blockstent Microcatheter demonstrated superiority over the AVP2, AVP4, and coils in several key performance characteristics during both the acute and chronic phases of the study, including deliverability, fluoroscopic conspicuity, time to complete occlusion, and degree of chronic occlusion.

Abstract No. 423

Beware of injuring the deep circumflex artery during paracentesis

M. Nashed1, J. Smith1, Loma Linda University Medical Center, Loma Linda, CA

Purpose: Paracentesis is a very commonly performed procedure by interventional radiologists as well as other specialists. A rare complication of this procedure is bleeding due to injury of an inferior epigastric artery (IEA) branch, which is well described in the literature, and which practitioners are taught to avoid. The purpose of this study is to highlight the deep circumflex iliac artery, which is the most commonly injured artery during paracentesis in our institutional experience. Anatomic considerations and steps to avoid this pitfall will be discussed.

Materials: This IRB-approved retrospective study included 14 patients identified through a data mining software (Montagne-Nuance Communications, Burlington, MA) who were referred to interventional radiology for embolization of hemorrhage after paracentesis from 2007 to 2017.

Results: Study included 5 females and 9 males with a mean age of 55, of whom 13 had underlying cirrhosis and 1 patient had ascites secondary to cardiomyopathy. Out of the 14 patients, 2 patients had a negative angiogram with no bleeding source identified. Eight patients (66%) had evidence of injury to the deep circumflex artery, while the remaining 4 patients (33%) had a combination of injuries to the inferior epigastric IEA and intercostal arteries; in these 12 patients, the injured arteries were treated with transcatheter embolization, with an overall technical success rate of 100% with some patients r

Conclusions: Though rare, the most common complication from paracentesis in this typically coagulopathic population is hemorrhage. Our results illustrate that both the well known inferior epigastric artery (IEA) as well as the lesser known deep circumflex iliac artery need to be considered both when performing paracentesis and treating their hemorrhagic complications. We hypothesize that in consciously avoiding the inferior epigastric artery, practitioners choose a puncture site that is too lateral along the iliac crest where the deep circumflex artery courses, resulting in...
A utility of the endovascular treatment for ruptured or unruptured aneurysms of the pancreaticoduodenal arcade

H. Kawada¹, S. Goshima¹, Y. Tanahashi¹, Y. Noda², N. Kawai², T. Ando², M. Matsuou³, ¹Gifu University Hospital, Gifu, Gifu; ²Gifu university Hospital, Gifu, Gifu

Purpose: The aneurysms of pancreaticoduodenal arcade (PArc-Ans), including gastroduodenal artery aneurysms (GDAAs) and pancreaticoduodenal artery aneurysms (PDAAs), are uncommon lesions associated with a significant risk of rupture. The purpose of this study was to evaluate the utility of endovascular treatment for PArc-Ans.

Materials: The records of all patients with GDAAs and PDAAs treated by transcatheter arterial embolization (TAE) between 2010 and 2016 were identified through an institutional database, and these records were retrospectively reviewed. Date on presenting symptoms, comorbid conditions, imaging findings, treatment approach, complications, observation period, and outcomes after treatment were examined.

Results: All patients were successfully treated by transcatheter arterial embolization (TAE) [two GDAAs (size; 13.9 mm, range: 13.3-14.4 mm) and 10 PDAAs (size; 11.2 mm, range: 4.3-26.8 mm)]. Three symptomatic aneurysms (25%) were only found in three ruptured patients who were all successfully treated by TAE. Six patients were associated with sever stenosis or complete occlusion of celiac axis due to the compression by median arcuate ligament. Most of them (5/6) were successfully treated by TAE alone. A patient with complete occlusion of celiac axis and multiple PDAAs were treated with a combination of TAE and bypass surgery. The average observation period after treatment was 14.9 months (range, 1-45 months). Overall 30-day morbidity and mortality after treatment were both 0.0%.

Conclusions: The TAE could be recognized as a safe and effective treatment technique for PArc-Ans with or without rupture.

Proximal splenic embolization: an important role for IR in the treatment of splenic trauma

P. Carrelli¹, K. Degeyter¹, D. Collins¹, L. Keating¹, K. Mandato², A. Herr¹, M. Englander³, C. Stark¹, G. Siskin¹; ¹Albany Medical Center, Albany, NY

Purpose: To review our recent institutional experience with proximal splenic embolization to treat splenic injury caused by blunt trauma and to review the role this procedure plays in the management of these patients.

Materials: A retrospective chart review of all trauma patients who had undergone splenic embolization for blunt splenic injury at our institution from January 2014-September 2017 was performed. Demographic information, mechanism of injury, AAST injury grade, angiography findings, and outcomes were then evaluated for all patients.

Results: 160 patients were included in this analysis (mean age = 40 years). Most of the splenic injuries were classified as either being either a Grade III (n = 74) or IV (n = 58). The splenic salvage rate was 98%. Three patients died during their hospitalization due to the extent of their injuries and/or underlying comorbidities. The major adverse event rate was 4.4% (n = 7) and included splenectomy (n = 3), rebleeding requiring additional embolization (n = 1), splenic infarction (n = 2), and development of an abscess (n = 1). The minor adverse event rate was 8% (n = 13) and included post-embolization syndrome (n = 9), return to the ED after discharge (n = 2), minor infection (n = 1), and other minor procedural complications (including groin hematoma).
(n = 1). The risk of a major adverse event correlated with higher AAST Injury Grade, as well as with angiographic findings of active extravasation and/or pseudoaneurysm.

**Conclusions:** IR has an important role to play in the multidisciplinary treatment of splenic trauma. Splenic embolization has been shown to significantly improve splenic salvage rates, although not without the risk of complications. Our reported splenic salvage rate of 98% demonstrates the important role that embolization should play in the management of these patients. Despite the acceptance of this treatment option, questions still remain regarding patient selection, long-term splenic function, and the role of prophylactic vaccination given possible deficiencies in immunologic function after embolization.

---

**Abstract No. 428**

**Uterine artery embolization in pig: an in vivo evaluation of the embolization effect of newly developed microspheres**

Y. Jeon1, B. Trong2, D. Lee3; 1Inha Universitiy St Hospital, Incheon, Republic of Korea; 2Inha University, Incheon, Republic of Korea; 3Inha University Hospital, Incheon, Republic of Korea

**Purpose:** To evaluate the embolization effect of newly developed microspheres on pig uterine artery (UA).

**Materials:** Twelve adult non-pregnant pigs, mean weight 50 ± 5 kg, were randomly allocated into three groups (4 pigs per group). Microspheres of 2 sizes, 300-500 μm (group A) and 500-700 μm (group B) were compared with non-calibrated gelatin sponge 350-560 μm (group C). Bilateral UA were superselected and embolized using 2.8F standard microcatheters. Seven days before embolization, each pig received an intramuscular administration of 6000 IU chorionic ganadotrophin for 3 days. Seven days after embolization, follow-up angiography was performed to quantify the degree of UA recanalization using a specific embolization score proposed by Stampfl et al. Pigs were immediately sacrificed thereafter and macroscopic necroses of uteri were visually evaluated using a score system proposed by Pelage et al. Each uterine horn and UA were considered independent for statistical analysis.

**Results:** Technical success rate was 100% without evidence of non-target embolization. No microcatheter occlusion occurred during embolization. There were no statistical differences in the median diameter of the UA and the median particle volume among the 3 groups (Kruskal-Wallis test). All uteri revealed necrosis on macroscopic inspection. The rates of extensive uterine necrosis of group A (75%) and B (87.5%) were significantly higher than that of group C (25%) (p = 0.024, Pearson Chi-square test). There were no evidences of total recanalization of UA among the 3 groups. Most of the UA of group A (87.5%) remained occluded at the level of the arcuate artery while those of group B and C remained occluded at the level of the radial artery (50%), however, the difference was not statistically significant (p = 0.074, Pearson Chi square test). Group B and group C had 2 UA main trunks occlusion while group A did not.

**Conclusions:** The newly developed microspheres 300-500 μm and 500-700 μm had devascularization effect on pig UA with extensive uterine necrosis. The occlusion was consistent after 7 days.

---

**Abstract No. 430**

**Repeat uterine artery embolization: update on indications and technical findings**

T. Caridi1, J. Yoon2, M. Manning3, J. Cardella4, J. Spies5; 1Georgetown University Hospital, Washington, DC; 2Georgetown University School of Medicine, Washington, DC; 3University Of Maryland Medical System, Baltimore, MD; 4Georgetown University Medical Center, Washington, DC

**Purpose:** To re-examine the indications and technical aspects of uterine artery embolization (UAE) in patients undergoing repeat UAE procedures.

**Materials:** At a single-center from 2006 to 2012, patients who underwent repeat UAE for recurrent, persistent, or new symptoms were identified. Magnetic resonance (MR) imaging before repeat embolization was compared to initial MR imaging (obtained prior to first embolization). The extent of fibroid infarction after the first procedure, growth of existing fibroids, and new fibroids were assessed. Procedure records were reviewed for technical aspects of first and second UAE procedures.
Results: 31 patients underwent repeat embolization 8 to 97 months after initial embolization. Most patients presented with recurrent menorrhagia (n = 17), pelvic pain/discomfort (n = 7), and urinary symptoms (n = 5). There was a single case presentation of anemia, and one of increasing fibroid size. MR imaging studies were available for 22 of 31 patients and these demonstrated 20 patients with incompletely infarcted fibroids post-initial embolization; one patient had interval enlargement of an existing fibroid and one patient continued to have symptoms despite complete infarction. No new fibroids were identified in this study group. During initial embolization, no patient underwent ovarian artery embolization. During repeat embolization, 6 patients required ovarian artery embolization.

Conclusions: Repeat UAE prompted by recurrence of symptomatic fibroids, in particular causing menorrhagia, is often secondary to incomplete infarction. Ovarian artery supply may have contributed to the lack of complete fibroid infarction in a portion of patients however this is not true for the majority of cases in this cohort. The data related to ovarian artery supply is consistent with a prior study from 2006 and therefore further investigation may be indicated to determine additional causes for lack of complete infarction, with the most likely cause being early vascular recanalization.

A retrospective analysis of clinical outcomes in patients who underwent proximal versus distal splenic artery embolization for traumatic splenic injuries

F. Kowalkowski1, L. Walker1, I. Patel2; 1University Hospitals Cleveland Medical Center, Cleveland, OH; 2University Hospitals Case Medical Center, Cleveland, OH

Purpose: The purpose of this study is to assess clinical outcomes of splenic angioembolization in patients with traumatic splenic injuries, and to further assess which technique is associated with improved clinical outcomes (proximal versus distal embolization).

Materials: 200 patients with traumatic splenic injuries were admitted to a level I trauma center from 10/2010 to 9/2017. The management method was determine using a retrospective analysis. Procedural reports were reviewed to determine whether a proximal or distal technique was used for embolization. Then, chart review was performed to record clinical outcome parameters including major rebleeding (requiring splenectomy), minor rebleeding (not requiring splenectomy), infection, and splenic inarction. Also, the AAST splenic injury grades were recorded. Outcomes were then compared between proximal and distal embolization, and stratified based on the AAST grades.

Results: 50 patients underwent splenectomy. 20 patients underwent splenic angioembolization (12 proximal, 6 distal, and 2 combination of proximal and distal). 5 of the total 20 patients (20%) had major rebleeding requiring splenectomy. The rate of major rebleeding for proximal embolization was 17% versus 33% for distal embolization. Of the 5 patients with major bleeding 4 had grade IV-V injuries and 1 had grades I-III injuries. In addition, 1 of the patients who had major rebleeding underwent a combination of proximal and distal embolization. The rate of minor rebleeding for proximal embolization was 8% compared to 0% for distal embolization. The rate of infarction for patients who had proximal embolization was 17% compared to 30% for distal embolization. Also, 1 out 2 patients undergoing a combination technique for embolization had a splenic infract. The rate of infection was 20% for the distal technique versus 0% for the proximal technique.

Conclusions: The rate of major rebleeding requiring splenectomy is not statistically different for patients undergoing distal embolization compared to proximal embolization. Minor complications were higher in patients undergoing distal embolization. This data also suggests AAST grades IV-V should go straight to splenectomy.

Trans-radial uterine artery embolization with the superior hypogastric nerve block: optimizing pain control and minimizing length of stay

S. Maratto1, S. Alkhatib1, J. Huang1, R. Fabrizio1, B. Hammelman1; 1Pennsylvania Hospital, Philadelphia, PA

Purpose: We aim to describe our experience using the trans-radial approach and the superior hypogastric nerve block in performing outpatient uterine artery embolization, focusing on postprocedure narcotic requirements and the time to discharge.

Materials: We reviewed the records of all outpatients who underwent trans-radial uterine artery embolization (UAE) with a superior hypogastric nerve block (SHNB) between April 2014 and August 2017. We perform trans-radial UAE and the SHNB in a manner similar to that which has been described112 excepting that we administer 20 ml of 0.5% bupivacaine anterior to the L5 vertebral body. Time required to perform the SHNB was measured as the time elapsed between the final post-embolization arteriogram and the last image documenting needle tip location for the nerve block. The postprocedural time to discharge was captured as the time between the last procedural image recorded and the later of the last set of vital signs or the time discharge instructions were printed. Additionally, we recorded narcotic administration intra- and postprocedure. We also noted patients admitted directly from recovery and those who re-presented for symptom control after discharge.

Results: Seventy-nine outpatients underwent trans-radial UAE with the SHNB. Bilateral trans-radial UAE was technically successful in 76 of 78 patients; the SHNB was successful in all but one patient. Average procedure time for the nerve block was 7 m 31s (range, 2 to 33 m). Five patients were admitted from the postprocedure area for pain or nausea control, and one patient was admitted for bleeding. 37 of 78 patients required no narcotic medications in the postprocedural setting. Median time to discharge was 2h 37 m (n = 72, range 0:25 to 6:45). Of these patients, six re-presented within five days for uncontrolled pain or nausea.

Conclusions: The trans-radial approach combined with a superior hypogastric nerve block can minimize narcotic use and time to discharge when performing outpatient uterine artery embolization.
Abstract No. 434

Retrospective comparison of preoperative splenic artery embolization
Y. Vazquez Perez1, S. Lowe2, G. Li3, C. Chao5; 1University of Maryland Medical Center, Baltimore, MD; 2N/A, Ellicott City, MD; 3University of Maryland, Baltimore, Baltimore, MD

Purpose: Some prior studies have suggested that proximal splenic artery embolization may be equivalent or superior to distal embolization for not only trauma/bleeding but also for preoperative splenectomy. To independently evaluate these findings, we performed a retrospective review of all preoperative splenic artery embolization performed from 20014 to 2017.

Materials: Review of imaging and medical charts was performed for all preoperative splenic artery embolizations by interventional radiology at a large academic institution for 4 years using either particles or Amplatzer plugs. Patient demographics, diagnosis/indication, fluoroscopy time, technique, time to surgery, spleen weight and volume and necessity of patient controlled analgesia (PCA) pain pump were reviewed. Volumetric software was used to calculate spleen volume.

Results: A total of 9 preoperative splenic artery embolization procedures were performed (average age 44). The most common indication for the proximal artery embolization was infection (splenic septic emboli or abscess) and for distal embolization was splenomegaly or portal hypertension. Mean fluoroscopy time using for proximal embolization was 13.5 minutes and for distal embolization was 15.1 minutes (p = 0.6). The mean blood loss for proximal versus distal embolization cases was 796 mL versus 143 mL (p = 0.038), respectively. The mean spleen weight and volume for proximal versus distal procedures were 445 g and 698 mL and 2005 g and 1645 mL (p = 0.3, p = 0.6), respectively. The mean blood loss per weight and per volume for proximal embolizations were 2.2 mL/g and 1.5 and for distal embolizations were 0.4 mL/g and 0.5 (p = 0.038, p = 0.2), respectively. A lower percentage of patients undergoing proximal embolization required PCA pain pump (33% versus 67%, p = 0.5).

Conclusions: Our preoperative splenic artery embolization series performed at a large academic center found significantly decreased blood loss with distal embolization. However, there was a lower percentage of patients using PCA pain pumps after proximal embolizations, which was not statistically significant.

Abstract No. 435

Is sickle cell disease protective against symptomatic uterine fibroids?
J. Shah1, J. Newsome1, Z. Bercu1, J. Mitchell1, D. Morris2, J. Martin1; 1Emory University School of Medicine, Atlanta, GA; 2Morehouse School of Medicine, Atlanta, GA

Purpose: To understand if sickle cell disease (SCD) may provide protection from symptomatic uterine fibroids (UF).

Materials: Two sets of consecutively presenting patients treated at three large academic medical centers in a single large urban area were analyzed. 156 adult African American (AA) symptomatic women treated with uterine fibroid embolization (UFE) were included, none of whom had SCD. 81 adult AA women treated with IR procedures associated with SCD were also included, none of whom had symptomatic fibroids. Only 3 patients in this SCD group had fibroids, these patients were asymptomatic and 35 years of age or older.

Results: When the two groups are compared via contingency table analysis, there was no association between the two conditions (SCD and presence of uterine fibroids, Pearson’s chi-square, df = 1, p = 0.000, OR = 4030, phi = -0.962, p = 0.000). Furthermore, the rate of uterine fibroids in our group of SCD patients is 3.7%. While rates of prevalence in populations vary based on literature sources, comparison with a 2003 epidemiological study of prevalence in premenopausal AA women, in which the rate is lower than in postmenopausal women, shows that our sample of SCD is not drawn from the same population (Pearson’s chi-square, df = 1, p = 0.000).

Conclusions: African-Americans have a high prevalence of SCD and UF, especially in comparison to other ethnicities. After looking at a large dataset of AA women treated by interventional radiology for sickle cell and uterine fibroid associated procedures, the groups are nearly mutually exclusive. The incidence of fibroids is significantly lower in this population of SCD patients when compared to the incidence of fibroids in all patients. Given our sample of women with SCD, SCD may be protective of uterine fibroids. However, more epidemiologic study is required.

Abstract No. 436

Partial splenic embolization for thrombocytopenia recovery to facilitate chemotherapy
A. Chen1, H. Ferral1, M. Alonzo1, S. Regalado1, T. Farrell1, L. Dalag2, R. Marsh1, T. Aquisto1; 1NorthShore University Health System, Evanston, IL; 2The University of Chicago, Chicago, IL

Purpose: To evaluate the efficacy of partial splenic embolization for the treatment of thrombocytopenia in patients with metastatic disease prior to, or following, initiation of chemotherapy.

Materials: Retrospective review was performed on 22 patients in a single institution over a 57 month time period (Nov. 2012 to Aug. 2017) who presented with metastatic disease and thrombocytopenia prior to, or following, initiation of chemotherapy. Malignancies consisted of pancreatic (11), colorectal (8), hepatocellular (1), gastrointestinal (1) and cholangiocarcinoma (1). Partial splenic embolization was performed by 1 of 6 operators using particles (300-500 or 500-700 micron) and pre- and postprocedure platelet counts were recorded. In addition, the time to recovery of platelet counts was recorded, thus allowing for initiation or continuation of chemotherapy. Postprocedural complications were monitored.

Results: Technical success for partial splenic embolization was 100%. No immediate complications were noted. Average pre-procedure platelet count was 84 (range, 60-141). Following partial splenic embolization, average postprocedure platelet count was 272 (126-459) and average time to platelet recovery was 23 days (7-62). When calculated as a percentage of platelet count increase from baseline, the average percentage of platelet count recovery was 246% (78-629%). No major complications were noted with the primary minor complication reported as pain. One patient had persistent pain 5 weeks postprocedure requiring narcotics. No hospitalizations for pain control reported.
Conclusions: Partial splenic embolization appears to demonstrate a favorable response in the recovery of thrombocytopenia in patients with metastatic disease. Recovery of platelet counts appears to be within a reasonable timeframe and allows for the safe initiation, or continuation, of systemic chemotherapy in this patient cohort with minimal delay to treatment. Overall complication profile is low.

Abstract No. 437

How much do fibers on embolic coils improve embolization efficiency?
R. Dunlap¹, K. Reichel², K. Hong³, ¹Johns Hopkins Hospital, Baltimore, MD; ²Johns Hopkins Hospital, Baltimore, MD; ³Johns Hopkins Hospital, Woodstock, MD

Purpose: Pushable embolic coils are manufactured in numerous styles and configurations. Fibered embolic coils remain the traditional mainstay in coil design. Yet, the impact of these fibers on embolization coils and how these fibers improve embolization are not well validated or studied. We aim to test the impact of these fibers utilizing the same detachable coil, with and without fibers using an animal swine model.

Materials: Standard commercially available 0.035 fibered coils were used; we specially acquired the same coils with the fibers removed. Occlusion efficiency was assessed by the number of coils used, unit length of coils, and the amount of time required for complete embolization. A total of 2 swine were used via a transfemoral approach. A total of 12 artery sites were embolized; matched 6 paired and similarly sized arteries (subclavian, inferior renal and internal femoral arteries). Each was subselected and embolized utilizing the same embolization protocol via a 5F JB1 catheter. Embolization was performed with detachable fibered coil on one side, and identical yet unfibered coil on the contralateral vessel. Standard clinical embolization practice and flow scoring (TIMI grading) was employed throughout.

Results: Average vessel size was similar for the fibered side (mean, 4.46 mm; range, 3.49-6.93 mm) vs non-fibered (mean, 4.74 mm; range, 3.33-6.99 mm). Average occlusion time was lowest for fibered coils with a mean time 7.16 min. vs 17.16 min in unfibered coils. Unit length coil used to achieve complete embolization was significantly less in fibered coil with a mean length of 28.3 cm (total, 170 cm) vs the unfibered which had a mean length of 60 cm (total, 360 cm).

Conclusions: Fibered coils have a substantially improved embolization efficiency over those without fiber in the same coil design as measured by embolization time, number of coils used, and unit length of coil used in an animal model. These fibers directly reduce embolization time and number of coils required for complete embolization, which may translate into a reduction in procedure times and costs.

Abstract No. 438

Novel hand ultrasound techniques as predictors of safety for transradial arterial access
A. Nasiri¹, J. Lee¹, V. Prasad¹, A. Bharadwaj¹, R. Strilaeff¹, V. Cha¹, S. Kiang¹, R. Tomihama¹; ¹Loma Linda University Medical Center, Loma Linda, CA

Purpose: Transradial arterial access is considered safe in the presence of a complete palmar arch. The Barbeau test is currently the standard of care in safety evaluation for transradial arterial access. We sought to compare two novel hand ultrasound techniques versus Barbeau testing as a screen for complete palmar arch.

Materials: Thirty-three patients in an ongoing prospective study at a single institution underwent palmar arch screening with Barbeau test, radial artery compression thenar space ultrasound (TSU), and princeps pollicis artery ultrasound (PPAU) prior to transradial arterial access. After access, digital subtraction angiograms were obtained in each patient. Using the angiograms as gold standard for complete arch, the test characteristics of the three screens were compared.

Results: Compared to hand angiography, Barbeau test demonstrated 100% sensitivity and 100% positive predictive value in detecting complete palmar arch. For radial artery compression TSU, in 4 (12.2%) patients, ultrasound not interpretable; in the remaining patients, the sensitivity and positive predictive value were: 96.4% and 100%, respectively. For radial artery compression PPAU, in 1 (11%) patient, ultrasound not interpretable; in the remaining patients, the sensitivity and positive predictive value were: 100% and 100%, respectively.

Conclusions: Although Barbeau testing remains the current standard in safety evaluation for transradial arterial access, preliminary data suggest that novel hand ultrasound techniques such as thenar space ultrasound and princeps pollicis artery ultrasound can be suitable alternatives in predicting palmar arch patency.

Abstract No. 439

Evaluation of blood loss and transfusion requirements in patients with invasive placenta treated with arterial occlusion balloons or internal iliac artery ligation
R. Cochran¹, M. Kohi², J. Moriarty³, P. Dong⁴, K. Nelson⁵, A. Picel⁶; ¹University of California San Diego, San Diego, CA; ²University of California, San Francisco, San Francisco, CA; ³UCLA Medical Center, Los Angeles, CA; ⁴UC Davis, Sacramento, CA; ⁵University of California Irvine, North Tustin, CA

Purpose: To evaluate the postoperative outcomes of patients who underwent cesarean hysterectomy for invasive placenta and were treated with either prophylactic internal iliac artery (IIA) or aortic occlusion balloons compared to IIA ligation.

Materials: A multi-institutional retrospective analysis from 2011 to 2017 identified 46 patients with invasive placenta treated with prophylactic occlusion balloons or IIA ligation. Blood loss and transfusion requirements were compared. 17 patients were treated with prophylactic IIA balloons, 11 patients with aortic occlusion balloons, and 18 patients with IIA ligation. Baseline demographics were not significantly different for patient age, gestational age at delivery, gravidity, parity or number of previous C-sections.

Results: Median estimated blood loss (EBL) for the 18 patients who underwent IIA ligation was 2.8 L (1.0-15 L) compared to 1.75 L (0.9-4 L) for the combined balloon occlusion group of 28 patients (p = 0.007). Patients treated with IIA ligation were transfused a median of 6 units (0-32 units) of packed red blood cells (pRBCs) compared to a median of 0 units (0-15 units) in the combined occlusion balloon group (p<0.001). Transfusion of
platelets and fresh frozen plasma were also significantly less in the balloon occlusion group compared to the ligation group (median 0 units vs 1 unit; p<0.001 and median 0 units vs 4.5 units; p<0.001). We next compared operative outcomes between the two occlusion balloon treatment groups. Median EBL was 1.5 L (0.9-4.0 L) in the IIA balloon group vs 2.0 L (1.0-3.0 L) in the aortic balloon placement group (p = 0.97). Transfusion requirements were not statistically different between the balloon occlusion groups.

Conclusions: Patients undergoing cesarean hysterectomy for invasive placenta managed with arterial occlusion balloons demonstrated significantly less EBL and transfusion requirements compared to patients treated with internal iliac artery ligation. Blood loss and transfusion requirements did not differ between the IIA and aortic occlusion balloon groups.

Abstract No. 440
Feasibility and safety of aortic balloon occlusion for management of obstetric hemorrhage with invasive placenta: initial results
E. Ihenachor1, S. Khan2, K. Nelson3, A. Picel4, P. Dong5, M. Kohi6, J. Moriarty7; 1David Geffen School of Medicine at UCLA, Los Angeles, CA; 2UCLA, Los Angeles, CA; 3University of California Irvine, North Tustin, CA; 4University of California San Diego, San Diego, CA; 5N/A, Sacramento, CA; 6University of California, San Francisco, San Francisco, CA; 7UCLA Medical Center, Los Angeles, CA

Purpose: Traditionally the definitive management of invasive placenta was planned preterm cesarean hysterectomy and has been associated with a high risk of catastrophic hemorrhage. Use of endovascular interventional procedures to reduce hemorrhage has been reported, with limited available evidence surrounding safety and efficacy. The aim of this study is to evaluate the feasibility and safety of aortic balloon occlusion to manage obstetric hemorrhage compared to patients who receive no interventions.

Materials: Patients who underwent aortic balloon occlusion prior to hysterectomy following preoperative diagnosis with placental implantation disorders between 2011 and 2016 at a tertiary referral center were retrospectively compared with a control group of multicenter registry patients who did not receive intervention. Endovascular occlusion technique, intraoperative blood loss, average length of hospital stay and postoperative complications were evaluated.

Results: 135 patients were included in this retrospective review, 11 received aortic balloon occlusion at the time of delivery, and were compared with 124 patients who received no intervention at the time of delivery. Invasive placenta was present in all patients in the aortic balloon and control groups: placenta percreta (n = 4 and 26); placenta increta (n = 4 and 48), placenta accreta (n = 3 and 50), respectively. The estimated blood loss in the operating room was lower in the aortic balloon group (1890.91 ± 656.44 ml) than the control group (2643.66 ± 1951.52 ml) (p = 0.008). The average length of hospital stay after the delivery was shorter for patients who received an aortic balloon (4.18 ± 0.87 days) compared to the control group (7.60 ± 8.96 days) (p = 0.001). No complications occurred among the 11 patients who underwent balloon occlusion of the abdominal aorta prior to hysterectomy.

Conclusions: Aortic balloon occlusion is a safe and feasible option compared to no intervention with favorable reduction in intraoperative blood loss and length of hospital stay.

Abstract No. 441
VIABAHN stent-graft placement for emergent/urgent cervical cerebrovascular artery disease: a single-center experience of 22 cases
M. Horikawa1, B. Petersen2, H. Bozorgchami1, J. Liu3, R. Priest4, 5Dotter Interventional Institute, Portland, OR; 6N/A, Portland, OR; 7Oregon Health and Science University, Portland, OR

Purpose: To report our single-center experience of Viabahn stent-graft placement for acute bleeding or pseudoaneurysms of innominate, cervical carotid, or vertebral artery in emergent/urgent clinical conditions.

Materials: A retrospective study was conducted between Jan 2003 and Sep 2017. A total of 22 patients (14 male, 8 female; age range 18–82 years, mean 65.6 years and median 56 years) were treated with 22 Viabahn stent grafts (9 carotid blow-out syndrome and 13 pseudoaneurysms with or without dissection: 4 innominate, 4 common carotid, 12 internal carotid, 1 both common and internal carotid, and 1 vertebral artery involvement). The stent-graft patency was evaluated by angiogram, contrast-enhanced CT, MRA, ultrasonography, or direct observation during surgery.

Results: The mean and median imaging follow-up periods were 740 and 193 days, respectively. Technical success was 100% (22/22). Dual antiplatelet agents were given in 20 patients either immediately before or after the deployment of the stent-grafts. No immediate procedure-related complications occurred. Two unstable patients with carotid blow-out syndrome died of severe systemic disturbance within 8 days, despite successful bleeding cessation by the procedure. Three patients underwent subsequent bypass surgery within 17 days for concern about infection. One stent-graft occlusion occurred 195 days after the procedure with unexpected cession of antiplatelet therapy. One significant hemorrhagic complication was observed and died 125 days after the procedure (esophageal agoutaneous fistula). Two patients were lost to follow-up. Among the remaining 13 patients, 11 patients demonstrated 6 months or longer stent-graft patency and 2 developed more than 50% stenosis.

Conclusions: Viabahn stent-grafting may be safe and useful for the management of emergent/urgent arterial bleeding or pseudoaneurysms involving cervical cerebrovascular arteries.

Abstract No. 442
MR PREDICTS: a reliable and useful tool in identifying benefit of mechanical thrombectomy in patients with large vessel occlusion
S. Majidi1, W. Olan2, D. Sigounas2, C Leon Guerrero2, A. Chun2, S. Sarin2, 1National Institutes of Health, Bethesda, MD; 2GWU, Washington, DC; 3George Washington University, Vienna, VA

Purpose: The AHA/ASA guideline recommends endovascular therapy for patients with acute ischemic stroke within 6 hours from
symptom onset. Identification of the patients most likely to benefit (and those most likely to be harmed) from reperfusion plays a pivotal role in decision-making. We applied the MR PREDICTS tool (clinical decision-making tool derived from MR CLEAN clinical trial) on a real-world sample of patients with acute ischemic stroke to assess its utility in predicting clinical benefit from endovascular therapy.

**Materials:** We identified all patients with acute ischemic stroke with occlusion of the distal internal carotid artery, proximal M1, or M2 segment of the middle cerebral artery who underwent endovascular reperfusion procedure (thrombectomy and/or intra-arterial thrombolysis) from July 2016 to June 2017. Patients were divided into two groups; those with a good outcome (90 Day mRS 0-2) and those with a poor outcome (90 Day mRS 3-6). The MR PREDICTS tool was used to determine absolute treatment benefit for each patient. This predicted outcome was compared to actual patient outcome.

**Results:** A total of 22 patients were identified. Eight patients had a good outcome and 14 patients had a poor outcome. The calculated absolute treatment benefit from endovascular therapy using the MR PREDICTS tool was consistently higher among patients in the good outcome group, with an average absolute treatment benefit of 12% greater among these patients compared to those in the poor outcome cohort (19% versus 7%). Of note, patients with a poor outcome had a higher rate of prior stroke, higher baseline NIHSS, longer symptom onset to groin puncture time, less favorable collateralization and lower rate of successful recanalization defined as TICI 2b or 3 (100% versus 64%).

**Conclusions:** There is a strong correlation between predicted treatment benefit by MR PREDICTS tool and actual patient outcomes which supports broader use of this tool during the decision-making process for endovascular therapy in patients with acute ischemic stroke.

---

**Abstract No. 443**

**Mechanical thrombectomy in patients with acute ischemic stroke on anticoagulation therapy**

M. Kocher¹, M. Cerna², D. Sanak³, F. Cihlar⁴, D. Cernik⁴; ¹University Hospital Olomouc, Olomouc, Olomouc; ²University Hospital Olomouc, Olomouc, Czech Republic; ³University Hospital Olomouc, Olomouc, Olomouc, Olomouc; ⁴Masaryk’s Hospital Ústí nad Labem, Ústí nad Labem, Czech Republic

**Purpose:** Mechanical thrombectomy (MT) can be performed also in acute ischemic stroke (IS) patients using anticoagulation therapy (AT), however reported data has not been still enough consistent. Our aim was assess the safety and efficacy of MT in patients on AT.

**Materials:** All consecutive IS patients treated with MT in both centers were enrolled in the retrospective analysis. In all patients, MT was performed using stent-retrievers, neurological deficit was scored using National Institutes of Health Stroke Scale (NIHSS) and 90day clinical outcome using modified Rankin scale (mRS) with score 0-2 for good outcome. Achieved recanalization was rated using Thrombolysis in Cerebral Infarction (TICI) scale. Symptomatic intracerebral haemorrhage (SICH) was assessed according to the SITS-MOST criteria.

**Results:** Out of 750 patients treated with MT, 76 patients (46% of males, mean age 73 years) were on AT with a median of admission NIHSS 16 points. 84% of patients had atrial fibrillation (AF). Overall recanalization was achieved in 90% and complete (TICI 3) in 78% of patients. ICH after MT was detected in 37% of patients and SICH in 11% of patients. 36% of patients had good outcome after 3 months. 7-day mortality was 8% and 37% of patients died within 3 months.

**Conclusions:** MT seems to be safe also in patients on AT. Poor outcome with high 3-month mortality might be associated with presence of AF. Acknowledgment: Supported by grant: IGA LF UP_010_2017, RVO FNOL_00098892_2016 and IGA-KZ-2016-1-2.

---

**Abstract No. 444**

**Endovascular revascularization of acutely thrombosed renal fenestration bridging stent grafts: initial experience**

S. Mafeld¹, G. Annamalai¹, S. Frosi Stella¹, K. Tan¹; ¹University Health Network, Toronto, ON

**Purpose:** We outline our experience with a previously unreported technique using AngioJet (Boston Scientific, MA) rheolytic thrombectomy in the management of acutely thrombosed renal fenestrated stent grafts. Fenestrated endovascular aneurysm repair (f-EVAR) is an evolving technique to treat abdominal aortic aneurysms in patients who are unsuitable for conventional infra-renal EVAR. The technique requires bridging stent grafts between the aortic graft main body and the visceral arteries. Visceral bridging stent graft patency with f-EVAR is high, approaching 90% at 4 years. Acute thrombosis of the visceral arteries post f-EVAR can have potentially catastrophic clinical outcomes and there is limited consensus and experience in managing this presentation.

**Materials:** Retrospective study of patients who underwent AngioJet rheolytic thrombectomy for acutely thrombosed visceral stent grafts following f-EVAR. The picture archiving and communication system (PACS) and electronic medical record (EMR) were reviewed for case details and outcomes.

**Results:** Three patients (all male; mean age, 81 years) presented acutely at a mean of 49 days post-f-EVAR with acute renal failure and confirmed renal fenestrated stent graft occlusion on computed tomography (CT). Two of the patients had solitary kidneys. All patients underwent AngioJet rheolytic thrombectomy, two patients underwent additional localized infusion of tissue plasminogen activator and one patient also required renal angioplasty and stent insertion. There was a 100% technical success rate defined as re-establishment of renal arterial flow. At mean follow-up of 14 days post procedure, there was a mean creatinine reduction of 33% and a 30% recovery in eGFR.

**Conclusions:** In our experience, AngioJet rheolytic thrombectomy is safe and technically successful in the management of acutely thrombosed renal fenestration bridging stents. It provides an effective, endovascular management option in this difficult to treat patient cohort.

---

**Abstract No. 445**

**Hypoxic stress induces the overexpression of programmed death ligand 1 and chemokine ligand 17 on rat hepatoma cell lines**

H. Takaki¹, Y. Hirata², E. Ueshima³, K. Kobayashi², Y. Kako², J. Taniguchi², K. Yamakado²; ¹Hyogo College

**Purpose:** Hypoxic stress induces the overexpression of programmed death ligand 1 and chemokine ligand 17 on rat hepatoma cell lines.
of Medicine, Nishinomiya-Shi, Hyogo; ²Hyogo College of Medicine, Hyogo, Japan; ³Kobe University Hospital, Hyogo, Japan

Purpose: Recent studies have shown that cancer cells escape from immune system by expressing immunosuppressive factors. Although interventional therapies for hepatoma such as hepatic artery embolization and thermal ablation induce hypoxia in the treatment site, effects of hypoxia for the expression of immunosuppressive factors are less understood. The purpose of this study is to evaluate the effects of hypoxic stress for the expression of immunosuppressive factors such as programmed death ligand 1 (PD-L1) and chemokine ligands (CCL) that attract regulatory T-cells (Tregs) on rat hepatoma cell lines.

Materials: 1 × 10⁶ rat hepatoma cell lines, N1S1 and RH7777, were plated in 10 cm cell culture dishes. Those cells were exposed to hypoxic conditions (hypoxia group, O₂:1%) or normoxic conditions (normoxia group, O₂:21%) for up to 24 hours. Cell numbers and viabilities were measured at 12 hours intervals. Messenger RNA (mRNA) expressions of immunosuppressive factors such as PD-L1, CCL17, CCL22 and CCL28 as well as vascular endothelial growth factor (VEGF) were evaluated by quantitative reverse transcription polymerase chain reaction (qPCR) at 12 hours intervals. All experiments were repeated 4 times (n = 4). Cell numbers, cell viabilities, and mRNA expressions of immunosuppressive factors were compared between hypoxia and normoxia groups in both cell lines.

Results: Cell numbers and viabilities at 12 and 24 hours were comparable between hypoxic and normoxic condition groups in both cell lines. Expressions of VEGF were significantly increased at 24 hours in hypoxia group than normoxia group (p<0.01 in both cell lines). The expressions of PD-L1 and CCL17 were significantly increased at 24 hours in hypoxia group than normoxia group in the RH7777 cell line (p<0.01 and p<0.03). On the other hand, no significant changes in the expression of mRNA those related to immunosuppression were observed in the N1S1 cell line.

Conclusions: Although hypoxic stress did not affect cell numbers and viabilities of rat hepatoma cells for up to 24 hours, it induced the overexpression of immunosuppression related mRNAs such as PD-L1 and CCL17 especially in RH7777 cell lines.

Abstract No. 447

Sublethal concurrent osmotic and thermal stresses readily overwhelm cytoprotective responses across multiple human hepatocellular carcinoma cell lines

N. Muñoz¹, U. Polak², C. Guo³, M. Gustin⁴, A. Minhaj³, E. Cressman⁵; ¹University of Texas MD Anderson Cancer Center, Houston, TX; ²The University of Texas MD Anderson Cancer Center, Houston, TX; ³UTMD Anderson Cancer Center, Houston, TX; ⁴Rice University, Houston, TX; ⁵University of Texas M.D. Anderson Cancer Center, Houston, TX

Purpose: Thermochemical Ablation (TCA) is a multiplexed, minimally invasive, image-guided method of tissue destruction, which combines hyperosmotic stress with hyperthermic ablation. It is anticipated that at the margins of a TCA-treated lesion, the concentration of salt would be lower than in the central region, and the hyperthermia would be both mild and relatively short compared to the core of the lesion. The aim of this study was to assess the generality of the effects of combining mild hyperosmotic and hyperthermic stresses on 4 hepatocellular cancer (HCC) cell lines.

Materials: Viability and clonogenicity of 4 HCC cell lines with different genomic landscapes, namely Hep3B, HepG2, SNU449, and SNU398 were assessed in triplicate after in vitro exposure to increasing concentrations (0-400 mM) of sodium acetate (NaOAc), and sodium chloride (NaCl) for 24h at 37°C. A subset was also exposed to a concurrent sublethal heat shock of 43°C for 3h at the onset of treatment.

Results: All cell lines tested proved very sensitive to combined mild stresses. Hep3B and SNU449 cells maintained limited viability (below 50%) whereas HepG2 and SNU398 were nearly undetectable (below 1% viability). A potent additive effect was
particularly evident for the combination of NaCl (over 100 mM) and heat. In addition, osmotic stress by NaCl alone induced a greater loss of viability than NaOAc alone at concentrations over 100 mM. Hep3B and SNU449 cells were relatively resistant to mild thermal stress alone (below 20% loss) compared to HepG2 and SNU398 lines, in which viability after the heat shock alone decreased considerably (over 70% loss). Clonogenic assays likewise demonstrated added toxic effects with combined stresses.

**Conclusions:** Simultaneous thermal and osmotic stresses even at low levels show additive cytotoxicity, and the effect was observed across all HCC cell lines tested. The magnitude of the effect in each case likely reflects a combination of effects including the genomic landscape of the tumor cells and their microenvironment. These results suggest that in the marginal zone of a TCA-treated tumor cells would experience persistent cytotoxic stress. TCA may prove effective in lowering local recurrence rates in HCC.

---

**Abstract No. 449**

**Shear wave elastography (SWE) as a quantitative biophysical assay to measure tumor stiffness changes after hepatic arterial embolization**

A. Cortes¹, U. Polak², S. Huang³, M. Hicks¹, R. Avritscher⁴; ¹The University of Texas MD Anderson Cancer Center, Houston, TX; ²The University of Texas MD Anderson Cancer Center, Houston, TX; ³MD Anderson, Houston, TX; ⁴MD Anderson Cancer Center, Houston, TX

**Purpose:** Real-time intraprocedural quantitative assays are sorely needed to measure tumor changes during hepatic arterial embolization (HAE). Current assays fail to depict tumor mechanical properties. Our purpose was to assess tumor stiffness changes in an orthotopic rat model of hepatocellular carcinoma (HCC) before and after HAE.

**Materials:** This study was approved by the institutional Animal Care and Use Committee. Rat hepatoma Mca-RH7777 cells were orthotopically implanted in the liver of 12 male Buffalo rats, and, after 3 weeks, the animals underwent HAE through a left common carotid approach. Bilobar bland embolization was performed using 70-150 μm LC beads until near-stasis. Normal liver and tumor stiffness was measured using ultrasound shear wave elastography (SWE) before and immediately after HAE.

**Results:** The overall mean tumor stiffness measured 15.2 kPa ± 7.6 (standard deviation) before HAE compared to 22.2 kPa ± 7.4 immediately after the procedure, P = .003. The peak tumor stiffness measured 18.2 kPa ± 9.7 (standard deviation) before HAE compared to 28.6 kPa ± 11.3 after the procedure, P = .006. Normal liver stiffness measured 4.8 kPa ± 2.1 before and 7.2 kPa after embolization, P = .008.

**Conclusions:** Our findings demonstrate significant acute increase in tumor stiffness after hepatic embolization. SWE offers a new perspective in real-time assessment of tumor mechanical changes during embolization. Further studies may help determine if this technique can be used to improve HAE intraprocedural efficacy.

---

**Abstract No. 450**

**The effects of partial irreversible electroporation (IRE) on T-cell and macrophage population in murine bladder tumor microenvironment**

L. Santos¹, M. Fujimori², L. Vroomen³, E. Ueshima⁴, K. Kim⁵, K. Nagar², J. Coleman², G. Srimathveeravalli³; ¹Shadyside Academy High School, Pittsburg, PA; ²Memorial Sloan Kettering Cancer Center, New York, NY; ³MSKCC/VUmc, New York, NY; ⁴Kobe University, Kobe, Hyogo; ⁵Memorial Sloan Kettering Cancer Center, Kew Gardens, NY

**Abstract No. 448**

**Comparison of electrochemotherapy and radiation for chemosensitization of drug resistant cell lines**

L. Vroomen¹, W. Vista¹, M. Fujimori¹, J. Humm¹, S. Solomon², G. Srimathveeravalli³; ¹Memorial Sloan Kettering Cancer Center, New York, NY; ²Memorial Sloan Kettering, New York, NY; ³Memorial Sloan Kettering Cancer Center, Kew Gardens, NY

**Purpose:** Bleomycin (BLM) can cause double strand DNA breaks similar to radiation (RT), but the use of BLM is limited by its slow transport into cells. Electrochemotherapy (ECT) refers to the combination of BLM with electroporation, which results in multifold increase of drug delivery to cells. The aim of this study was to determine whether ECT can be used as an alternative to RT for enhancing chemotherapy.

**Materials:** Two brain cancer cell lines (T98G & U87) known to be resistant to Temozolomide (TMZ) and Olaparib (OLA) were used for this study. 3D tumor models were constructed by seeding cells in collagen scaffolds, and were assigned at random to the following cohorts: (1) Sham, (2) TMZ, (3) OLA, (4) ECT, (5) ECT+TMZ, (6) ECT+OLA, (7) RT, (8) RT+TMZ, (9) RT+OLA.

**Results:** Chemotherapy alone had modest effect on proliferation of T98G (BLM:87% ± 5%, TMZ:58% ± 2%, OLA:48% ± 5%) and U87 (BLM:88% ± 3%, TMZ:39% ± 5%, OLA:77% ± 2%) following 72h of treatment. RT alone had no impact on cell proliferation while ECT induced a modest decrease in both cell lines (T98G:42% ± 3%; and U87:23% ± 4%). Compared to drug monotherapy, combination of both TMZ (T98G:20% ± 1% and U87:14% ± 2%) and OLA (T98G:20% ± 0% and U87:23% ± 7%) with ECT was associated with a significant reduction in cell proliferation in both cancer lines (p = <0.005). The chemosensitization effect of ECT was greater than RT (after 5Gy = TMZ:62% ± 1% and 46% ± 1%; OLA:56% ± 1% and 72% ± 1% for T98G and U87, respectively) (after 10 Gy TMZ:70% ± 1% and 51% ± 0% and OLA:58% ± 0% and 74% ± 3%, for T98G and U87, respectively) for both cell lines (p = <0.005).

**Conclusions:** When compared to RT, ECT can rapidly and effectively chemosensitize drug resistant cell. ECT can be performed percutaneously, providing the added benefit of focal therapy that spares normal tissue from DNA damage.
Reversal of the Warburg phenotype by promotion of pyruvate dehydrogenase activity decreases hepatocellular carcinoma resistance to targeted anti-cancer therapies

E. Fagbongbe1, D. Das2, G. McLennan2; 1Cleveland Clinic Foundation, Cleveland, OH; 2Cleveland Clinic, Chagrin Falls, OH

Purpose: To test the hypothesis that reversing the Warburg effect by sodium phenylbutyrate sensitizes HCC cells to MTOR inhibitor treatment.

Materials: Patient derived primary HCC cells were cultured in Williams' Media E supplemented with 10% fetal bovine serum, 1% PS, FGF, EGf, insulin and dexamethasone. Cells were treated with increasing concentrations of PhBA (0–15 mM) for 24 hours and 48 hours, and increasing concentrations of PhBA combined with fixed rapamycin concentration for 24- and 48-hours. Cell growth/cytotoxicity was measured as OD at 490nm using a Microtiter kit from Promega. rapamycin, Na-PhBA, insulin, dexamethasone, and PS were purchased from Sigma. FBS was purchased from Denville. FGF and EGF were purchased from R&D Scientific.

Results: Cytotoxicity assays showed dose-dependent and time-dependent toxicity in 2 primary HCC cell lines at 24- and 48-hours when exposed to PhBA. In HCC-11 at 24 hours, percent cytotoxicity was 5%, 14%, 15%, 32%, 68% for 0.25-mM, 0.5-mM, 1-mM, 5-mM PhBA, respectively. In HCC-11 at 48 hours, percent cytotoxicity was 23%, 30%, 38%, 54%, 80% for 0.25-mM, 0.5-mM, 1-mM, 5-mM, 15-mM PhBA, respectively. In HCC-37 at 24 hours, percent cytotoxicity was 13%, 13%, 18%, 30%, 47% for 0.25-mM, 0.5-mM, 1-mM, 5-mM, 15-mM PhBA respectively. In HCC-37 at 48 hours, percent cytotoxicity was 14%, 7%, 9%, 36%, 76% for 0.25-mM, 0.5-mM, 1-mM, 5-mM, 15-mM PhBA, respectively.

Conclusions: Data shows a dose- and time-dependent effect of PhBA on primary HCC cells. Further studies will be needed to characterize the PhBA/rapamycin interaction.
Abstract No. 453

Mechanical thrombectomy in acute thrombosis of dialysis fistulas using the Indigo aspiration system: a multi-center study

C. Marce1, Y. Le Bras2, F. Petitpierre2, N. Grenier2, J. Van Den Berg3, B. Huasen4; 1Chu Pellegrin Imagerie Mediceale Pr Grenier, Bordeaux, France; 2CHU Bordeaux, Bordeaux, France; 3N/A, Cantello (VA), Italy; 4Preston, Preston, England

Purpose: To prospectively analyse the technical and clinical outcome of percutaneous thrombectomy aspiration using the Indigo System in acutely thrombosed dialysis fistulas.

Materials: Patients with acute thrombosis of their dialysis fistula (native AVF and prosthetic grafts AVG) were prospectively enrolled in Bordeaux University Hospital, Preston University Hospital and Lugano’s Centro Vascolare Ticino Hospital. From June 2016 to April 2017, 35 patients with an average age of 61.8 years (range, 33-81) presenting with thrombotic events in dialysis fistulas were prospectively evaluated for mechanical thrombectomy using the Indigo system. Adjunctive therapies and procedure related complications were noted. Technical success, clinical success, primary patency, primary assisted patency, and secondary patency of the dialysis fistula were assessed. Technical success is defined as the ability to recanalize the dialysis fistula, and clinical success, defined as successful dialysis session postprocedure.

Results: Mean follow-up time was 8.5 months (3-12). Technical efficacy was 97.1% (34/35). Clinical success was 91.4% (32/35). Complications include; a single patient developed a hematoma around the fistula during dialysis from the haemodialysis needle access puncture site, not causing cessation of his dialysis session, 1 patient who thrombosed his dialysis fistula 24 hours after treatment (underlying stenosis was not sufficiently venoplastied/dilated), 1 patient who had an uncomplicated perforation of the vein, without re-clotting his dialysis fistula, due to his fragile vessel and skin status (steroid/drug related). Adjunctive procedures for the primary underlying cause, mostly stenosis, included balloon angioplasty (94% 33/35), and stent graft deployment (5.7% 2/35). Other Mechanical/Aspiration thrombectomy systems were used in the primary stage at the French site include, Arrow-Trerotola (2.8% 1/35) and Fogarty (5.7% 2/35) to clear the thrombus burden. Upon failing to achieve access results or due to failure, the clinicians used

Conclusions: Percutaneous mechanical thrombectomy aspiration of thrombosed dialysis fistulas with Indigo system is a fast and safe procedure with low complication rate and an effe

Abstract No. 454

Percutaneous interventions for hemodialysis access: national trends in . . . the Medicare population

O. Ahmed1, R. Rabei2, K. Patel1, M. Patel3, M. Ginsburg4, B. Clayton1, B. Arslan1; 1Rush University Medical Center, Chicago, IL; 2Rosalind Franklin Univ Med and Sci, Chicago, IL; 3University Of Chicago Medicine, Chicago, IL; 4Palos Health, Hinsdale, IL

Purpose: To evaluate annual national trends in hemodialysis access maintenance procedures in the Medicare population by provider and setting.

Materials: Medicare Physician Supplier Procedure Summary Master Files between 2005-2015 were analyzed for procedure code. Hemodialysis access angiography and percutaneous thrombectomy. Using physician specialty codes, component procedure volume for endovascular services were queried for radiology, medicine, and surgery. Data entries were analyzed by provider type and place of service. Average submitted and allowed charges per intervention were extracted. Linear regression modeling was used to identify trends in number of and allowed charges by specialty and practice setting.

Results: Between 2005-2015, the total Medicare fee-for-service beneficiary frequency of dialysis access angiography increased by a total of 74.71% (211,181 to 368,955). Specialty specific analysis demonstrated volume increase of 220.21% (22,128 to 101,109) for surgery, 249.02% (32,690 to 114,094) for medicine and an increase of 2.81% (135,564 to 139,367) for radiology. By 2015, an increased trend from hospital to non-hospital based procedures associated with significantly higher reimbursement rates to providers (+$18,798 non-hospital based cases/year, $46.95/year, p = <.001) was also observed, with medicine performing the highest volume of non-hospital based cases. In this period, there was also a modest total overall increase of percutaneous thrombectomy procedures by 7.75% (61,465 to 66,250).

Conclusions: The frequency of endovascular hemodialysis access maintenance procedures in the Medicare fee for service program has increased from 2005-2015 with the majority market share transitioning from radiologists to non-radiologists. Similarly, the majority of access maintenance in this time period changed from hospital to non-hospital based interventions.

Abstract No. 455

The arteriovenous dialysis circuit: an underappreciated factor in ESRD patients with heart failure

V. Wu1, J. Cui1, R. Vazquez1, R. Schainfeld2, Z. Irani1; 1Massachusetts General Hospital, Boston, MA; 2Harvard Medical School, Waltham, MA

Purpose: Arteriovenous fistulas (AVF) are low resistance circuits that increase cardiac demand and may result in high-output heart failure in patients with end-stage renal disease (ESRD). Banding reduces access circuit flow and its demand on the heart. This study aims to investigate the effects of AVF banding on cardiac function and clinical outcomes in hemodialysis patients presenting with heart failure.

Materials: A retrospective review was performed on ESRD patients with AVF who underwent fistulograms, right heart catheterizations, and interventions during the same procedure between January 2016 and September 2017. Relevant clinical data and imaging were assessed. Spearman’s rank correlation test was used to determine the strength of associations between variables. A two-tailed value of p < 0.05 was considered statistically significant.

Results: 10 patients (80% male, mean age of 67 ± 13) with heart failure were referred for hemodynamic evaluation and possible access banding. Access banding was not performed in 4 (40%) of these patients due to either unfavorable anatomy or lack of high AV access flow (mean flow of 1.3 ± 0.1 L/min). 6 (60%) patients that underwent image-guided access banding had recurrent syncope, dyspnea, or intestinal angina during dialysis sessions, flash pulmonary edema, or cardiogenic shock. The mean age of their AV shunts
was 36 ± 18 months. There was a strong positive correlation between the age of AV shunts and their prebanding fistula diameter (r = 0.812, p = 0.05). Mean fistula diameter was 12.20 ± 0.1 and 4.80 ± 0.02 mm before and after access banding, respectively. Real-time cardiac output measured during fistulograms had a mean of 6.40 ± 0.07 and 5.20 ± 0.03 L/min before and after banding. Mean cardiac index was 3.40 ± 0.03 and 2.80 ± 0.02 L/min/m² before and after banding. Their average follow-up was 9.8 ± 3.5 months, during which time none of the patients had a relapse of their prebanding presentations.

**Conclusions:** Access banding can be used to decrease cardiac output, as demonstrated by real-time right heart catheterization. This strategy may play a role in the management of heart failure in ESRD patients suspected of having high flow access.

**Abstract No. 456**

Assessing the impact of anticoagulant and antiplatelet therapy for patients undergoing tunneled dialysis catheter interventions: a retrospective review

E. Siddiqui1, R. Ruttiman2, G. Dubel3, S. Ahn4; 1Rhode Island Hospital, Brown University, Providence, RI; 2Brown University, Providence, RI; 3Alpert School of Medicine of Brown University, Providence, RI; 4Alpert Medical School of Brown University, Rumford, RI

**Purpose:** Minimally invasive procedures such as tunneled dialysis catheter placements remain an indication for withholding anticoagulant and antiplatelet therapy prior to the procedure. This study aims to investigate the benefit, if any, of withholding anticoagulant and antiplatelet therapy prior to tunneled dialysis catheter placements.

**Materials:** We retrospectively reviewed tunneled dialysis catheter placements performed at an academic teaching hospital between March 2015 and August 2017. Patient age, sex, antiplatelet and anticoagulant status, and complications were recorded. Patients were divided based on their anticoagulant and antiplatelet status into 3 groups: currently on therapy (group 1), therapy discontinued for procedure (group 2), not on therapy (group 3). Complications included death within 30 days, transfusion, procedure related hemorrhage requiring minor or major intervention, or increase in level of care. Descriptive statistical analysis was followed by chi-square test and multivariate logistic regression analysis after adjusting for age and gender, done using SPSS 24.0.

**Results:** Out of 181 patients undergoing tunneled dialysis catheter placements, 37 (20.4%) were in group 1, 58 (32.0%) in group 2, and 86 (47.5%) in group 3. Mean age was 56.9 ± 19.2 years and 115 (63.5%) were males. Total of 27 patients had complications: 6/37 (16.2%) in group 1, 11/58 (19.0%) in group 2, and 10/86 (11.6%) in group 3. Pearson chi-square test revealed statistically insignificant difference in complication rates among the three groups (p-value 0.465). As per multivariate logistic regression analysis when compared with group 3, the odds of developing a complication after procedure were 1.3 times for group 1 (p-value 0.609) and 1.5 times for group 2 (p-value 0.443), suggesting a trend towards higher complication rates in group 2.

**Conclusions:** Withholding anticoagulant and/or antiplatelet therapy prior to tunneled dialysis catheter placements has similar complication rates as patients on therapy during procedure, suggesting no benefit of withholding them and thus unnecessarily delaying the procedure and time-sensitive patient care. Large scale studies such as clinical trials can help validate these findings.

### Abstract No. 457

Randomized trial comparing the VectorFlow to Palindrome tunneled dialysis catheter

G. Nadolski1, A. Brandis2, B. Himmelman3, R. Fabrizio4, J. Redmond1; 1University of Pennsylvania, Philadelphia, PA; 2Palindrome, Philadelphia, PA; 3N/A, Philadelphia, PA

**Purpose:** Tunneled dialysis catheters (TDC) remain an important bridge to permanent hemodialysis (HD) access, a critical transition to new access creation when surgical access fails, and the only source of HD access for those who have exhausted their venous anatomy for surgical access options. Selection of a TDC capable of providing efficient HD with high primary patency is of utmost importance to improving outcomes in ESRD patients. The purpose of this trial is to compare a widely used symmetrical tip TDC,
Palindrome (P), to a recently FDA approved symmetrical design with helical flow at the tip to reduce blood cell shear stress, VectorFlow (VF).

**Materials:** The target recruitment of this study was 80 patients enrolled at two centers with 1:1 randomization of subjects between the two arms. Exclusion criteria included uncorrectable coagulopathy or thrombocytopenia; neutropenia, bacteremia, or infected surgical HD access within 7 days prior to enrollment; central venous stenosis or occlusion preventing jugular catheter insertion. The primary endpoint was primary patency at 90 days. Secondary end points included secondary patency, catheter flow and lumen pressures at initial HD sessions and then monthly for 3 months, as well as dialysis adequacy with Kt/V and URR monthly for 3 months.

**Results:** At present, the trial has enrolled 68 subjects and is anticipated to complete enrollment and reach primary end point for all subjects prior to deadline for late breaking abstracts for the 2018 SIR annual meeting. Investigators anticipate reporting comparison of 90-day primary patency of the two arms and analysis of secondary endpoints including catheter flow and lumen pressures and measures of HD adequacy up to 90-days after catheter insertion at the time of presentation.

**Conclusions:** The ongoing trial comparing VectorFlow tunneled dialysis catheter to Palindrome tunneled dialysis catheter is the first US randomized trial comparing different HD catheter tip designs in over a decade and the first to address dialysis adequacy. The results of this trial may elucidate which catheter design provides optimal HD adequacy and catheter patency.

---

**Abstract No. 458**

**Defining the hemostatic disorders of end-stage renal disease: platelet dysfunction is just the tip of the iceberg**

M. Chapman1, E. Moore2, H. Moore3, P. Rochon4, D. Johnson5; 1University of Colorado, Aurora, CO; 2University of Colorado, Denver, CO; 3University of Colorado School of Medicine, Denver, CO; 4University of Colorado Denver, Centennial, CO

**Purpose:** The hemostatic disorders in end-stage renal disease (ESRD) are complex and poorly understood. ESRD patients are conventionally thought to have a bleeding diathesis, but many paradoxically suffer from frequent thrombotic occlusion of their hemodialysis access, contributing to significant morbidity and expense. We sought to characterize, in detail, the pathophysiology of coagulation and fibrinolytic disorders in ESRD, both to determine predictors of access failure, and as a step toward developing new prophylactic agents for prevention of hemodialysis access thrombosis.

**Materials:** We compared blood from 75 consecutive ESRD patients undergoing hemodialysis access construction to 134 healthy volunteers. We utilized multi-channel thrombelastography (TEG) to characterize the patients’ coagulation and fibrinolytic systems. The TEG Functional Fibrinogen assay was used to assess fibrinogen levels. Platelet function was assessed using TEG Platelet Mapping, activated with arachidonic acid. The fibrinolytic system was tested with tPA-Challenged TEG, wherein exogenous tPA is added to the TEG cup, and fibrinolysis quantified as the 30-minute lysis (LY30).

**Results:** ESRD patients were resistant to exogenous tPA fibrinolysis, with a clot lysis in 30 minutes of 34.2% compared to 52.6% for healthy controls (p<0.0001, two-tailed Mann-Whitney test). ESRD patients also had significantly higher levels of functional fibrinogen than healthy controls at 575 versus 471 mg/dL (p<0.0001). Platelet activation, conversely, was decreased in ESRD patients, with a TEG Platelet Mapping maximum amplitude of 53.8 versus 62.5 for healthy controls (p = 0.0002). These data are summarized in the table.

**Conclusions:** ESRD patients have profoundly impaired fibrinolysis and elevated fibrinogen levels compared to healthy controls. Conversely, their platelet function is significantly impaired. These findings are consistent with the clinical observations of prolonged capillary bleeding, with a paradoxical prothrombotic state leading to dialysis access failure. This new insight suggests potential avenues for the development of new prophylactic agents, aimed at up-regulating the fibrinolytic system.

<table>
<thead>
<tr>
<th>TEG Assay</th>
<th>Healthy Controls (n = 134)</th>
<th>End-Stage Renal Disease (n = 75)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Median IQR</strong></td>
<td><strong>Median IQR</strong></td>
<td><strong>Median IQR</strong></td>
<td></td>
</tr>
<tr>
<td>Functional fibrinogen</td>
<td>471 (401-529)</td>
<td>575 (520-671)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>tPA response (TEG LY30)</td>
<td>52.6 (38.2-63.8)</td>
<td>34.2 (19.3-43.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Platelet activity (AA)</td>
<td>62.5 (57.0-66.5)</td>
<td>53.8 (39.4-62.9)</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

---

**Abstract No. 459**

**Evaluating outreach and potential of an online webinar-based interventional radiology elective**

V. Kumar1, S. Marcus2, A. Diaz3, E. Lehrman4, J. LaBerge5, M. Wilson6; 1University of California, San Francisco, San Francisco, CA; 2UCSF, San Francisco, CA; 3UCSF, San Francisco, CA; 4Loma Linda University, Loma Linda, CA; 5University of California San Francisco, San Francisco, CA; 6San Francisco General Hospital, San Francisco, CA

**Purpose:** To evaluate the efficacy of a webinar-based interventional radiology (IR) elective for outreach to institutions without robust preclinical IR exposure.

**Materials:** Between January and March 2017, eight 50-minute didactic sessions were broadcast, recorded and distributed over the internet in the form of a webinar-based elective using GoToWebinar software. SIR Connect Portal and social media platforms Twitter, Facebook and LinkedIn were used for promotion and advertising. Registrants and attendance was measured at each session, including the location of all registrants/attendants. This information was cross-referenced with a list of IR Interest Groups, the SIR directory, and the list of approved IR residency and fellowship programs. Student perceptions of IR careers were surveyed after the first session, and after the final elective sessions. All statistical analyses used Fisher’s exact test.

**Results:** Total registration included 83 institutions viewing from 29 states, and 9 countries. Eight Doctor of Osteopathy (DO) medical programs were included (10%). Out of 83 institutions,
Teaching image-guided procedures on human donors to increase medical student interest in interventional radiology residency

D. Barbon1, P. Laage-Gaupp2, R. Feinn1, R. Gonzalez1, D. Silin1; 1Frank H. Netter, MD School of Medicine at Quinnipiac University, North Haven, CT; 2Yale School of Medicine, New Haven, CT

Purpose: The purpose of this study is to determine if teaching image-guided procedures on human donors can impact medical student interest in IR residency, and to assess which factors medical students consider most relevant when choosing their residency.

Materials: This is an IRB-exempt study. Pre-surveys were sent to students at the Yale School of Medicine (SOM) and Frank H. Netter M.D. SOM at Quinnipiac University. Selection committees invited 20 participants to the IR Procedure Course: A four-hour, hands-on course where students learned image-guided procedures on human donors and ultrasound phantom models. Post-surveys were distributed at the end of the course. Results were analyzed using Wilcoxon signed rank and Exact tests.

Results: The 17 students that completed both surveys and attended the course were included in our study (29.4% female). Medical student participants included: Two First-Year, ten Second-Year, four Third-Year, and one Fourth-Year. Prior to our course, 52.9% had no exposure to IR procedures. There was a statistically significant increase in perceived IR knowledge from “not knowledgeable at all” to “slightly knowledgeable” from pre-to post-survey ($p = 0.009$). Questions about interest in IR education all demonstrated the same positive trend but failed to show a significant difference between surveys. Students ranked strong practical teaching in IR, and wide case spectrum as the most important factors when choosing an IR residency program. After our course, 88.2% of students stated they were either “definitely” or “probably” interested in an IR elective. And 47.1% of students were either “definitely” or “probably” interested in an IR residency program.

Conclusions: The use of human donors to teach image-guided procedures in an imaging suite leads to increased perceived IR knowledge in medical students. IR residency programs may consider emphasizing their strong practical IR curriculum and wide case spectrum to enhance medical student interest in their programs. Future studies should further investigate the impact of integrating regular image-guided procedure courses into the medical school curriculum.

Perception of interventional radiology and its influence among women trainees

Y. Koethe1, V. Kumar1, N. Kothary2, G. Hwang2, M. Kohi1; 1University of California, San Francisco, San Francisco, CA; 2Stanford University Medical Center, Stanford, CA

Purpose: Given the transition of interventional radiology from a fellowship to an integrated residency, increased exposure for medical students to the field is necessary. Running a shadowing program, however, can be time consuming and requires some resources. We developed and preliminarily evaluated the use of an automated email script built into google documents to determine whether it could allow for efficient and increased exposure of first year medical students to interventional radiology.

Materials: An automated shadowing program was developed within google documents using a custom send reminder service. Students signed up for slots onto a portal google document. They automatically received arrival instructions, as well as a pre- and post-survey, the day before and after the rotation respectively. Faculty and staff were copied onto the service emails to be aware of the student coming with the associated need for scrubs and point of service.

Results: Two months of data were analyzed. Within 1 week of utilization 36/48 (75% of available shadowing spots) were filled through the first semester. Of those that had shadowed during the first two weeks (7), students reported preshadowing, being familiar with IR 2/5, being interested in IR at 3/5, understanding the difference between IR and DR as well as about the integrated program 3/5, with 0 being an SIR member. After shadowing, students responded: being familiar with IR 4/5, being interested in IR 4/5, difference between IR and DR 4/5, and still a 3/5 in hearing of the integrated IR residency program. By using the program, minimal extra staff time was required on a day to day basis to coordinate.

Conclusions: We find that the use of the automated shadowing program enables higher exposure of medical students to interventional radiology with relatively little overhead.

Abstract No. 461

Development of iShadow, an automated shadowing program to expose first year medical students to interventional radiology

A. Som1, O. Akinwande2, S. Connolly3, R. Ramaswamy4, G. Foltz5; 1Washington University in St. Louis, St. Louis, MO; 2Washington University School of Medicine in St. Louis, St. Louis, MO; 3Washington University St. Louis, Mallinckrodt Institute of Radiology, St. Louis, MO; 4Mallinckrodt Institute of Radiology, St. Louis, MO

Purpose: With the transition of Interventional Radiology (IR) from a fellowship to an integrated residency program, increased exposure to IR procedures becomes necessary. Running a shadowing program however, is time consuming and requires some resources. We developed and preliminarily evaluated the use of an automated email script built into Google Documents to determine whether it could allow for efficient and increased exposure of first year medical students to interventional radiology.

Materials: An automated shadowing program was developed within Google Documents using a custom send reminder service. They automatically received arrival instructions, as well as a pre- and post-survey, the day before and after the rotation respectively. Faculty and staff were copied onto the service emails to be aware of the student coming with the associated need for scrubs and point of service.

Results: Two months of data were analyzed. Within 1 week of utilization 36/48 (75% of available shadowing spots) were filled through the first semester. Of those that had shadowed during the first two weeks (7), students reported preshadowing being familiar with IR 2/5, being interested in IR at 3/5, understanding the difference between IR and DR as well as about the integrated program 3/5, with 0 being an SIR member. After shadowing, students responded: being familiar with IR 4/5, being interested in IR 4/5, difference between IR and DR 4/5, and still a 3/5 in hearing of the integrated IR residency program. By using the program, minimal extra staff time was required on a day to day basis to coordinate.

Conclusions: We find that the use of the automated shadowing program enables higher exposure of medical students to interventional radiology with relatively little overhead.
Purpose: In 2015, women comprised of 47.6% of US medical graduates, which translated into 26.7% female radiology and diagnostic radiology residents and fellows, but only 9.3% of female interventional radiology (IR) residents and fellows (1). This represents a decline from 2010, when women comprised 15.4% of female IR fellows (2). As perceptions can influence career choices, this study aims to evaluate the preconceptions of IR among female trainees.

Materials: A single-day “Women in IR” (WIR) outreach session was arranged by three female faculty interventional radiologists involving fellows, residents, and medical students from two academic institutions. Prior to attendance, all trainees were invited to participate in an anonymous online survey (6 sections with 23 questions).

Results: 13 trainees (5 fellows, 5 residents, and 3 medical students) answered the pre-outreach survey. While all trainees believed that pursuing IR can fulfill potential career goals of direct patient care, high percentage of procedural work, and high salary, 38.5% did not believe that work-life balance can be achieved. Regarding lifestyle changes, many considered duration of training of 6-7 years (23.1%), extended daily work hours beyond training (38.5%), and call responsibilities in IR (46.2%) as deterrents in their pursuit of IR. Furthermore, despite existing data that pregnancy and fetal outcome among pregnant interventional radiologists matches that of the general population (6), nearly half (46.2%) were worried about occupational radiation exposure. 38.5% of attendees did not consider IR to be inclusive of women, and equal number considered male predominance in the field of IR as a deterrent to their pursuit of IR.

Conclusions: In addition to concerns over work-life balance and occupational radiation exposure, many trainees did not believe that IR is inclusive of women, and perceive male predominance as a deterrent to pursuing a career in IR. Continued effort to recruit women into IR should address diversity and inclusiveness, occupational radiation exposure, and issues of career life balance.

Abstract No. 463

Interventional radiology symposium increases medical student interest and identifies target recruitment candidates

M. Makary¹, A. Rajan¹, R. Miller¹, E. Elliott¹, G. Guy¹; ¹The Ohio State University Medical Center, Columbus, OH

Purpose: To assess and raise medical student (MS) interest in interventional radiology (IR) and awareness of the available training pathways via a state-wide IR Symposium; and to evaluate MS response across gender, level of training, and surgical vs nonsurgical specialty interest.

Materials: All Ohio MS were invited to an IR Symposium held by a large academic medical center in central Ohio in January 2017. The program encompassed didactic lectures covering the breadth of IR, hands-on simulation models, and a networking luncheon with faculty, trainees, and industry partners. All attendees completed an anonymous, 5-point-Likert scaled 9-question survey before and after attending the event to assess their awareness of IR as a specialty, understanding of the current training pathways, and level of interest in the field. Paired Wilcoxon signed rank test was used for statistical analysis.

Results: A total of 46 participants (M:F 60:40%, MS1-53%, MS2-36%, MS3-11%) from two medical schools attended the symposium. All MS have IR clerkships offered at their home institution, 26% attended a prior IR Interest Group event, and 20% participated in a previous IR symposium. The overall cohort demonstrated increased interest in pursuing a career in IR following the symposium (4.12 vs 3.70, p<.001). MS with an interest in a non-surgical specialty showed an increased interest in IR (4.20 vs 3.68, p<.001), whereas surgically oriented MS did not demonstrate a significant increase (4.00 vs 3.71, p = 0.375). No statistically significant differences were noted between the MS of different genders or level of training. The symposium experience significantly increased understanding of the IR training pathways (4.51 vs 2.94, p<.001). MS rated lectures (57%) and endovascular simulators (41%) as the most useful experiences.

Conclusions: This study demonstrated the importance of IR symposia for improving MS awareness of IR and IR training pathways. Findings were validated across both genders and level of training, and identified the subset of MS with nonsurgical interests as most responsive to such intervention and potential recruitment.

Abstract No. 464

Early career interventional radiologists: who are they, and what issues are most pressing to them? M. Khaja¹, L. Wilkins², B. Majdalany³, R. Pyne⁴, C. Couture⁵, M. Rajebi⁶, L. Findeiss⁷; ¹University of Michigan, Ann Arbor, MI; ²University of Virginia, Charlottesville, VA; ³University of Michigan Medical Center, Ann Arbor, MI; ⁴IR Residency Program Director, Rochester General Hospital, Pittsford, NY; ⁵SIR, Fairfax, VA; ⁶University of Colorado, Denver, CO; ⁷University of Tennessee Graduate School of Medicine, Knoxville, TN

Purpose: To report demographics, practice & employment patterns, Societal needs, and preferences of interventional radiologists (IR) early in their careers.

Materials: A 28-question survey aiming to understand who comprises early career IRs, issues that affect their practices and specific needs was distributed via email link which was active from August 1 through August 20, 2014.

Results: 213 responses were received from IRs in the US. 181 (87%) of respondents were male with 156 (73%) who were less than 40 years old. 167 (79%) were happy with their choice of IR as a career. 111 (50.9%) IRs reported over $100,000 in educational debt. 46 (23%) respondents have changed jobs since completing their training with 38 (77.6%) staying in their first job for at least 2 years. The most common identified subspecialties of respondents were oncologic interventions (n = 101, 48.1%), venous interventions (n = 61, 29.1%), and peripheral arterial interventions (n = 49, 23.3%). Career advancement, practice issues/disagreements, and compensation were the main reasons for changing jobs. 79.9% of early career IRs would be interested in serving as mentors for trainees and 77.8% were at least satisfied with the
mentoring relationships they have had in their careers. 178 (97.3%) felt that early career IRs have different needs and priorities, compared to established IRs. Respondents felt that mentorship, identification of barriers facing early career IRs, and networking are the most important functions of the Early Career Section. Respondents were most interested in business of Medicine topics at the SIR Annual Meeting. Early career IRs turn to SIR to provide them with CME, business of medicine, and practice management content most frequently.

Conclusions: Nearly a quarter of early career IRs changed jobs within 2 years for various reasons. They have specific needs and rely on SIR to provide resources for practice development and mentorship.

Abstract No. 465

Making a case for more IR residency positions: comparing qualifications of medical students applying to IR/DR residencies to NRMP DR match data
R. Pillai1, B. Roudsari2; 1University of California, Davis, Sacramento, CA; 2UC Davis Medical Center Department of Radiology, Sacramento, CA

Purpose: To compare measurable qualifications of medical students applying to diagnostic radiology (DR) and interventional radiology/diagnostic radiology (IR) programs in order to promote and support creation of new IR residency positions.

Materials: NRMP DR match outcome data (2016) and survey data from medical students applying for the upcoming match were used to compare measurable qualifications of medical students applying to IR residencies with those who match into DR residencies.

Results: DR data was based on NRMP data from 652 US allopathic seniors who matched in 2016. A total of 32 medical students completed the survey. Out of the students surveyed, 100% are respondents were in their match application year (75%) and 100% felt that early career IRs have different needs and priorities, compared to established IRs. Respondents felt that mentorship, identification of barriers facing early career IRs, and networking are the most important functions of the Early Career Section. Respondents were most interested in business of Medicine topics at the SIR Annual Meeting. Early career IRs turn to SIR to provide them with CME, business of medicine, and practice management content most frequently.

Conclusions: Nearly a quarter of early career IRs changed jobs within 2 years for various reasons. They have specific needs and rely on SIR to provide resources for practice development and mentorship.

Abstract No. 466

Review of clinical integration in interventional radiology residency program block schedules
N. Guta1, J. Mandel2, J. Fleming3, M. Noor4, C. Molloy5, G. Vatakencherry6, 1University of Arkansas of Medical Sciences, Little Rock, AR; 2St. George’s University School of Medicine, Bethpage, NY; 3Vanderbilt University School of Medicine, Nashville, TN; 4Osceola Regional Medical Center, Ocoee, FL; 5Kaiser Permanente, Los Angeles, CA; 6Kaiser Los Angeles medical center, Los Angeles, CA

Purpose: Since interventional radiology (IR) residency programs were established in 2014, little is known about what constitutes an optimal Integrated IR residency curriculum. The purpose of this study was to evaluate and compare the extent of clinical training in available IR residency program block schedules & to provide prospective IR trainees with an easily accessible resource for curriculum information.

Materials: The websites of all 65 ACGME-accredited programs were investigated for available IR Residency block schedules from June 2017 to July 2017. Program block schedules with insufficient detail were excluded from the study. Personal correspondence was used to obtain block schedules that were not available online. Descriptive statistical analysis was performed.

Results: The rotation block schedules of 27 programs were obtained. 19 of 27 programs assessed had sufficient detail for analysis. We evaluated scheduled IR rotations & IR-related clinical rotations which included; ICU, Vascular Surgery, Hepatology, etc. The mean number of IR blocks during the first three years of training (PGY2-4) is 4. 63% of programs scheduled >4 IR blocks during PGY2-4. Six programs scheduled at least 1 IR-related clinical block during PGY2-4, while 13 programs (68%) scheduled zero IR-related clinical blocks during PGY2-4. During the more senior PGY5-6 years, the mean number of IR blocks is 20. The mean number of IR-related clinical blocks during PGY5-6 years is 3. Overall, the mean number of total IR blocks scheduled (PGY2-6) is 24. The mean total of IR-related clinical blocks (PGY2-6) is 4. Only 11 programs scheduled >4 IR-related clinical blocks. Required IR-related clinical electives varied between institutions.

Conclusions: IR training is shifting toward increased emphasis on clinical training. From the minority of programs, which have made block schedules available to applicants, the data suggests wide variation in clinical experiences and many programs currently lack significant clinical rotations in PGY2-4. This data will help guide applicants in their decisions about programs. Future analysis should seek to determine whether the variation between IR program curricula has an effect on training.

Abstract No. 467

Assessing the role of mentorship in supporting medical student interest in IR
J. D’Souza1, L. Park2, M. Patil3, E. Alexander4, V. Kumar5, P. Rochon6, S. Ahn7; 1University Of Pennsylvania, Philadelphia, PA; 2The Warren Alpert Medical School of Brown University, Providence, RI; 3Alpert Medical School of Brown University, Monroe Township, NJ; 4University of Pennsylvania,
Purpose: Medical student awareness of and interest in interventional radiology (IR) is critical in recruiting future trainees, especially with the advent of the integrated IR residency. This study assesses the importance of IR mentorship to current medical students.

Materials: IRB approval was obtained and the study was HIPAA compliant. Anonymous electronic surveys were emailed to participants of medical student interventional radiology symposia before and after symposia and were available to attendees at symposia via smartphone mobile devices. Survey questions addressed topics including mentorship, academic opportunities in IR, and knowledge of and perception of IR. The mentorship portion of the survey addressed: 1) timing of mentorship during training, 2) assessing interest in connecting with an IR mentor, and 3) assessing the influence of an IR mentor on career decisions, using a 5-point Likert scale.

Results: Pre-symposium surveys were completed by 93 students (41% response rate), and postsymposium surveys were completed by 82 students (37% response rate). Demographics of respondents are as follows: MS1 11%, MS2 25%, MS3 40%, MS4 21%; Male 58%, Female 42%; White 48%, Asian 34%, Hispanic/Latino 5%, Black/African American 2%. Other 10%. 88% of students reported interest in connecting with an IR mentor (strongly agreed or agreed). An additional 11% were neutral, and only 1% of students disagreed. Moreover, 45% of students reported that having a first IR mentor influenced their career decision. Most of these students reported an IR mentor was most influential during medical school (55%) and 10% during college.

Conclusions: A large majority of medical students surveyed are interested in connecting with an IR mentor, and IR mentors have influenced many IR-oriented students’ career decisions. Creating and supporting mentorship opportunities for medical students must be a priority in outreach to medical students to increase interest in IR.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Count</th>
<th>%</th>
<th>Subject</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical question: specific case</td>
<td>249</td>
<td>30.1</td>
<td>General</td>
<td>353</td>
<td>42.8</td>
</tr>
<tr>
<td>Announcement</td>
<td>136</td>
<td>16.4</td>
<td>Vascular</td>
<td>231</td>
<td>28.0</td>
</tr>
<tr>
<td>Clinical question: general</td>
<td>121</td>
<td>14.6</td>
<td>Oncologic</td>
<td>74</td>
<td>8.97</td>
</tr>
<tr>
<td>Protocol/practice guidelines</td>
<td>87</td>
<td>10.5</td>
<td>Gynecologic</td>
<td>41</td>
<td>4.97</td>
</tr>
<tr>
<td>Product/equipment</td>
<td>60</td>
<td>7.26</td>
<td>Hepatobiliary</td>
<td>39</td>
<td>4.73</td>
</tr>
<tr>
<td>Question (general/nonclinical)</td>
<td>48</td>
<td>5.80</td>
<td>Gastrointestinal</td>
<td>20</td>
<td>2.42</td>
</tr>
<tr>
<td>Coding/billing</td>
<td>31</td>
<td>3.75</td>
<td>Venous access</td>
<td>18</td>
<td>2.18</td>
</tr>
<tr>
<td>Error</td>
<td>31</td>
<td>3.75</td>
<td>Urologic</td>
<td>17</td>
<td>2.06</td>
</tr>
<tr>
<td>IR residency</td>
<td>29</td>
<td>3.51</td>
<td>Orthopedic</td>
<td>13</td>
<td>1.58</td>
</tr>
<tr>
<td>Other</td>
<td>20</td>
<td>2.42</td>
<td>Neurologic</td>
<td>11</td>
<td>1.33</td>
</tr>
<tr>
<td>Business development</td>
<td>15</td>
<td>1.81</td>
<td>Dialysis</td>
<td>8</td>
<td>0.97</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>827</td>
<td>100</td>
<td><strong>Total</strong></td>
<td>825</td>
<td>100</td>
</tr>
</tbody>
</table>

Abstract No. 468

Improving patient care through social media collaboration: qualitative analysis of the first two years of posts on the SIR Connect forum

S. Koh¹, X. Han¹, J. Morrison¹; ¹Oregon Health & Science University, Portland, OR
Abstract No. 469

Representation of developing countries in interventional radiology research
W. Choi\(^1\), P. Yi\(^1\), T. Kim\(^1\), E. Huh\(^1\), A. Lee\(^1\), F. Hui\(^1\); 
\(^1\)Johns Hopkins University, Baltimore, MD

**Purpose:** The developing world accounts for greater than \(\frac{3}{4}\) of the global population, yet prior studies have shown a disproportionately low representation of developing countries in the medical literature. No prior study has assessed the participation of authors from the developing world in interventional radiology (IR) journals. The purpose of this study was to determine the representation of studies from developing countries in two influential IR journals.

**Materials:** We reviewed all articles published from January 2014 through December 2016: 1) *Journal of Vascular and Interventional Radiology* (JVIR) and 2) *CardioVascular and Interventional Radiology* (CVIR). The country of origin of the first author was identified for each study. Each country was grouped into either “developed” or “developing” based on designations provided by the International Monetary Fund. We compared representation of developing countries by journal and year using Chi-Square tests with Freeman-Halton extension, as appropriate.

**Results:** 1300 articles were reviewed from 2014 to 2016, of which 153 (12%) were from developing countries. The most prevalent developing country was China with 88 articles (58%), followed by Turkey with 24 (16%), India with 13 (8%), and Brazil with 9 (6%). Excluding China, only 5% of articles were from developing countries. In contrast, the United States accounted for 462 articles (36%), followed by Japan with 113 (9%). There was significantly less representation of developing countries in JVIR (9%) compared with CVIR (15%) (\(p = 0.003\)). There was no significant difference in representation of developing countries between the years (\(p = 0.3\)).

**Conclusions:** Developing countries are disproportionately underrepresented in two influential IR journals. Further study is needed to determine reasons for this low representation and to develop strategies to increase the number of IR publications from parts of the world where the disease burden is greatest.

---

Abstract No. 471

Development of a femoral vascular access curriculum: training medical students and residents for safe, real-world vascular access
G. Laidlaw\(^1\), A. Sheu\(^2\), J. Feli\(^2\), B. Triana\(^2\), C. Goetti\(^2\), R. Shah\(^2\); \(^1\)University of Washington, Seattle, WA; \(^2\)Stanford Medicine, Stanford, CA

**Purpose:** Ultrasound (US) guidance in femoral arterial access reduces complications and access time relative to palpation-guided access. Training is a critical component in performance; in a recent study, residents undergoing US-guided access simulation training outperformed experienced physicians. The purpose of this project was to develop an effective simulation-based training session for femoral arterial access targeted at medical students.

**Materials:** Our training curriculum was designed according to best practices in simulation-based education. A training video was recorded using Camtasia (Techsmith, Okemos, MI) software. Simulated US-guided arterial access demonstrations were delivered by interventional radiology (IR) physicians using femoral access training models, and students practiced real-time US-guided access proctored by IR physicians. Questionnaires assessing subjective training outcomes on a 5-point Likert scale were administered after sessions.

**Results:** 32 students viewed a training video reviewing femoral anatomy, femoral access indications and contraindications, US guidance, Seldinger technique, and step-by-step femoral arterial access instructions. An IR provider then demonstrated femoral access on an ultrasound-compatible simulation model. Each student practiced US-guided access with coaching and real-time feedback provided by the IR physician. 28 (87.5%) and 30 (93.8%) of students agreed or strongly agreed that the training video and vascular access models, respectively, were helpful in teaching femoral arterial access. Subjective confidence in performing access increased in 31 (96.9%) students (\(p<0.001\)), with a Likert score increase of \(\geq 2\) points in 22 (68.8%) students.
**Conclusions:** Generation of a succinct, effective simulation-based training session can help improve trainee confidence in arterial access. Such sessions are easily scaled to fit different group sizes and experience levels, and have been integrated into medical student curricula at our institution. These sessions can be expanded to include residents and fellows across multiple disciplines.

**Abstract No. 472**

**SIRPAC: characterizing donor behavior and crafting future fundraising strategies**

M. Drabkin1, J. Brown2, J. Donaldson3, J. Huang4, A. Klobučar5, M. Loya1, M. Moussa6, K. Patel1, P. Rotolo8, J. Gornal9, D. Huynh8, A. Misono8; 1Nassau University Medical Center, East Meadow, NY; 2VCU Health System, Henrico, VA; 3Cleveland Clinic Akron General, Akron, OH; 4Pennsylvania Hospital, University of Pennsylvania, Philadelphia, PA; 5University of Pittsburgh Medical Center, Pittsburgh, PA; 6UAMS, Little Rock, AR; 7Wayne State University, Detroit, MI; 8Miami Cardiac & Vascular Institute, Miami, FL; 9SIR, Fairfax, VA

**Purpose:** This project aims to identify factors associated with Society of Interventional Radiology (SIR) member donations to the Society of Interventional Radiology Political Action Committee (SIRPAC); this will enable more targeted fundraising efforts that should lead to increased donations.

**Materials:** A cross-sectional survey designed by the SIR Resident, Fellow and Student Section (RFS) Advocacy Committee was emailed to 4,474 SIR members including practicing interventional radiologists, residents, and fellows. Principal factors investigated include personal and professional demographics, donor history, and knowledge of the federal advocacy process as it pertains to IR. Basic summary statistics were compiled and logistic regression analysis was performed to determine factors influencing donor behavior.

**Results:** A total of 336 (7.5%) SIR members completed the survey. Overall, 119 (35.4%) members reported having donated to SIRPAC in the past year. Members whose annual income is more than $450,000 were 2.5 times more likely to donate relative to those who earn less than $450,000 (95% CI: 1.54-4.08; P < 0.001). Stratifying by years of experience, those with <5 years in practice were 1.9 times more likely to donate compared to members with >5 years in practice (95% CI: 1.16-3.05; P < 0.001). Additionally, members with good knowledge of the federal advocacy process were 3.8 times more likely to donate to SIRPAC than those who have no knowledge (95% CI: 1.69 - 8.60; P = 0.001). The majority of respondents, 259 (77.1%) reported having limited or no knowledge of the federal advocacy process. However, 206 (61.3%) respondents indicated that they were more likely to donate after completing the survey.

**Conclusions:** SIR members’ knowledge of the federal advocacy process, annual income, and years in practice were identified as key factors influencing donations. We plan to increase donations to SIRPAC by raising awareness of SIRPAC and the federal advocacy process, as well as by using targeted fundraising strategies aimed at higher earners.

**Abstract No. 473**


P. Agarwal1, C. Hawkins2, Y. Golowa3, J. Gans1, J. Cynamon4, 1Montefiore Medical Center, Bronx, NY; 2Emory University School of Medicine, Decatur, GA; 3Montefiore Medical Center, New York, NY; 4Montefiore Medical Center, Suffern, NY

**Purpose:** To analyze the usage metrics, stakeholders, and networks involved in the twitter IR community. -Understanding patterns will help guide doctors and organizations in designing future campaigns and augment SIR’s mission

**Materials:** From January 1, 2014 to September 24, 2017, the Symplur Signals platform was queried using five specific hashtags for a total of 76,342 tweets (#IRAD: 58,515 tweets), (#withoutscalpel 6,025 tweets), (#MIIP 5,411 tweets), (#filterOUT 5,076 tweets), (#transradial 1315 tweets) Analyses performed: 1. Activity (Number of Users, tweets), (#transradial 1315 tweets) Analyses performed: 1. Activity & Networks 2. Cumulative Tweets & Cumulative Users 3. Stakeholders 4. Location of Users & Tweet Languages

**Results:** #IRAD has highest usage metrics (82,028,711 impressions; 10.5 tweets per user, with a total of 5,551 users). Cumulative tweets are increasing at either linear or exponential rate, with #IRAD: 58,515 tweets), (#withoutscalpel 6,025 tweets), (#MIIP 5,411 tweets), (#filterOUT 5,076 tweets), (#transradial 1315 tweets) Analyses performed: 1. Activity & Networks (Including impressions, mentions, retweets, & engagement) 2. Cumulative Tweets & Cumulative Users 3. Stakeholders & Networks 4. Location of Users & Tweet Languages

**Conclusions:** Detailed data driven analysis of hashtag usage in interventional radiology may be helpful in guiding efforts to advance SIR’s mission -Concerted efforts must be made to help drive IR specific hashtag usage among patients.

<table>
<thead>
<tr>
<th>Hashtag Metrics 2014-2017</th>
<th>Impressions</th>
<th>Tweets</th>
<th>Tweets Per Month</th>
<th>Tweets Per User</th>
<th>Cumulative Tweet Growth Rate (Curve fitting analysis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#IRAD</td>
<td>82,028,771</td>
<td>58,515</td>
<td>1289</td>
<td>10.5</td>
<td>Exponential R² = 0.922</td>
</tr>
<tr>
<td>#Withoutscalpel</td>
<td>5,801,487</td>
<td>6025</td>
<td>133</td>
<td>5.34</td>
<td>Exponential R² = 0.904</td>
</tr>
<tr>
<td>#MIIP</td>
<td>4,576,581</td>
<td>5411</td>
<td>119</td>
<td>5.94</td>
<td>Linear R² = 0.992</td>
</tr>
<tr>
<td>#FilterOUT</td>
<td>4,326,213</td>
<td>5076</td>
<td>112</td>
<td>5.8</td>
<td>Linear R² = 0.954</td>
</tr>
<tr>
<td>#Transradial</td>
<td>2,719,277</td>
<td>1315</td>
<td>29</td>
<td>2.8</td>
<td>Exponential R² = 0.895</td>
</tr>
<tr>
<td>Combined</td>
<td>99,452,329</td>
<td>76,342</td>
<td>1682</td>
<td>8.5</td>
<td></td>
</tr>
</tbody>
</table>
Abstract No. 474

Readability of Spanish-language patient education materials from RadiologyInfo.org

E. Huh1, P. Yi1, F. Hui2; 1Johns Hopkins, Baltimore, MD; 2Johns Hopkins Hospital, Baltimore, MD

Purpose: The United States currently has the second-largest group of Spanish-speaking citizens in the world with 41 million native Spanish speakers. However, little attention has been paid towards assessing patient comprehension of Spanish-language healthcare educational materials. The purpose of this study was to assess the readability of patient educational materials written in Spanish from the RadiologyInfo.org website.

Materials: All patient education articles written in Spanish available in 2017 from the American College of Radiology (ACR) and Radiological Society of North America (RSNA)-sponsored RadiologyInfo.org patient education library were reviewed. We assessed each article for readability using 3 quantitative readability scales validated for assessing Spanish written text: Gilliam-Pena-Mountain scale, Larsbarheft formula (LIX) Rate Index formula (RIX), and SOL formula (modified-SMOG). The number of articles with readability ≤ the 8th grade level (average reading ability of US adults) and the 6th grade level (NIH-recommended level for patient education materials) were determined.

Results: 131 patient education articles were reviewed. The mean readability grade level was greater than the 11th grade reading level for all readability scales. Only 1 article was written at less than the eighth grade or the sixth grade levels.

Conclusions: Spanish-language patient educational materials provided by the ACR and RSNA-sponsored RadiologyInfo.org website are written at levels too high for the average patient. These findings are consistent with several prior studies assessing radiology-related patient educational materials written in English. Future efforts should be made to improve the readability of these patient education materials for English and Spanish-speakers alike.

Abstract No. 475

Follow the money: VIREX, a novel composite index to track reimbursement and the value of interventional radiology

V. Kadakia1, M. Hyatt1, K. Kadakia2, R. Trojan1; 1INTEGRIS Baptist Medical Center, Oklahoma City, OK; 2University of Texas Southwestern Medical Center, Dallas, TX

Purpose: Propose a composite of procedures and their reimbursements to be calculated into an index for tracking changes over time and demonstrating the value of IR.

Materials: The authors aim to select procedures that are a core representation of IR. Variables considered include volume, complexity, procedure times (length and consistency), and groupings (peripheral vascular, biliary, urinary, dialysis, etc.). 12 IR procedures are selected consistent with the initial number of companies in the Dow Jones Industrial Average. As with the Dow and S&P 500 stock indices, selection of procedures and their weighing in the index is based on objective parameters, i.e. volume, but also on less objective parameters, i.e. perceived importance. Private insurance typically mirrors the Centers for Medicare and Medicaid Services (CMS), making it the dominant healthcare player and thus useful in assessing the value of services. The CMS fee schedule assigns CPT code(s) to IR procedures to determine payment. Numerous factors alter the exact reimbursement: Facility vs. nonfacility, medicare administrative contractor (MAC), specific modifiers, and multiple procedure payment reduction (MPPR). Facility and non-facility pricing are both important as IR is practiced in both environments. Other variables such as MAC are controlled for by using the National Payment Amount. The “Standard Payment Adjustment” paradigm is used when MPPR is appropriate.

Results: Analysis reveals interesting findings regarding the trending of individual procedures as well the composite. For example, the global reimbursement for both IVC filter placement and dialysis circuit de-clot have both decreased relative to inflation and in absolute terms, but the latter decrease is nearly 30% compared the former’s paltry 0.2% decrease.

Conclusions: Why does Wall Street have all the tools? Value has become one of the dogmas of healthcare economics. Much like analogous stock market indices, our proposed composite index, the VIREX, can serve as a barometer to evaluate the changing value of IR. As an example, VIREX could be applied to illustrate the effects of policy change, show the value of IR to healthcare executives, and even assess the impact of SIR efforts.

Abstract No. 476

Clinical significance of liver vein infiltration in patients with hepatocellular carcinoma

S. Schotten1, S. Koch1, A. Weinmann1; A. Mehringer-Kunz1, F. Meyer1, R. Kloeckner1; 1University Medical Center, Mainz, Germany

Purpose: Portal vein tumor thrombosis (PVTT) significantly impairs the prognosis of patients with hepatocellular carcinoma (HCC) and classifies them as advanced stage (BCLC-C). However, the relevance of liver vein infiltration (LVI) remains unclear. Aim of this study is to compare the prognosis of patients with different forms of macrovascular infiltration as this might influence the choice of treatment.

Materials: 1378 HCC-patients were extracted from the clinical registry of our tertiary referral center treated between 01/2005-01/2017. Macrovascular infiltration was diagnosed by re-evaluation of all available CT- or MRI-studies by two experienced radiologists in consensus reading. Overall survival (OS) was calculated from the date of initial diagnosis for all subgroups (no infiltration, PVTT, and LVI). In case of macrovascular infiltration, OS was additionally calculated from the date of its first appearance.

Results: 1341 patients could finally be included. 807 patients had no infiltration, 491 showed PVTT, and 43 an isolated LVI. OS from initial diagnosis was: 37.29, 6.53, and 16.03 months, respectively (p<0.001). The OS calculated from the first appearance of macrovascular invasion was 4.90 months for PVTT, and 7.33 months for isolated LVI. The difference in OS was significantly different between these subgroups (p = 0.018).

Conclusions: Isolated LVI showed significantly better survival compared to patients with PVTT. This renders the question if patients with isolated LVI should be treated by means of systemic therapy, like BCLC-C patients, or if a local approach might also be justified.
Abstract No. 477

Enhancement ratio on arterial phase computed tomography can predict distribution of 99mTc-macroaggregated albumin in hepatocellular carcinoma

F. Syed¹, J. Bullen¹, R. Gurajala¹, K. Karuppasamy¹; ¹Cleveland Clinic, Cleveland, OH

Purpose: Technetium-99m-macroaggregated albumin (99mTc-MAA) scintigraphy is used to simulate hepatic 90Y radioembolization distribution. In partition model dosimetry, the tumor to background normal liver (T/N) ratio estimated from Tc-MAA scintigraphy is used to prescribe 90Y dose. This requires infusion of 99mTc-MAA into the liver. The aim of this study was to investigate the level of agreement between the T/N ratio as measured by arterial phase multidetector computed tomography (A-MDCT) and the ratio as measured by single-photon emission CT (SPECT) Tc-MAA scintigraphy.

Materials: Institutional review board approval was obtained for this retrospective review of patients with hepatocellular carcinoma. Between January 2014 and June 2017, 22 patients (mean age 64 years; 20 male) underwent A-MDCT before undergoing 99mTc-MAA SPECT. Volumes of interest delineated in the tumors (n = 46) and in the background lobe on A-MDCT were registered with 99mTc-MAA SPECT. T/N ratio was calculated on A-MDCT (ratio of Hounsfield units [HU]) and SPECT (ratio of counts). Enhancement of the lobar portal vein (PV) was recorded from A-MDCT. To quantify the amount of disagreement in T/N ratios, a discrepancy factor (DF) was calculated (ratio between the ratios on A-MDCT and SPECT). Spearman’s rank correlation coefficient was used to quantify the association between PV enhancement and DF.

Results: The median T/N HU ratio on A-MDCT was 1.6 (range, 1.1-2.7); the count ratio on SPECT was 2.0 (range, 0.2-8.9). The T/N ratio on SPECT was higher than the ratio on A-MDCT in 72% of lesions. The DF was ≤2 in 65% of lesions and ≤3 in 83% of lesions. When the PV HU was <70, there was a strong positive correlation between the PV HU and DF (r = 0.76). Higher PV enhancement demonstrated poorer correlation (r = 0.27).

Conclusions: There is agreement between the distribution of iodinated contrast material measured by A-MDCT in hepatocellular carcinoma and background liver and 99mTc-MAA particles measured by SPECT. Adherence to a standardized acquisition of the arterial phase that avoids PV enhancement reduces the discrepancies between A-MDCT and SPECT T/N ratios.

Abstract No. 478

Shearwave elastography for characterization of tumor heterogeneity in the rabbit liver VX2 tumor

D. Sotiadias¹, G. Sideris¹, J. Rhone¹, E. Liapi¹; ¹Johns Hopkins University, Baltimore, MD

Purpose: To evaluate the diagnostic performance of shear wave elastography (SWE) imaging for differentiating normal liver from tumor and characterizing tumor heterogeneity in the rabbit liver VX2 cancer model.

Materials: Nine rabbits were implanted with VX2 tumor in liver and imaged with conventional US and SWE 2-3 weeks after tumor implantation. Depending on tumor size, up to 12 ROI were placed in tumor and up to 8 ROI in normal liver. The mean, standard deviation and range of SWS values (m/s) and elastic modulus (SWEM, KPa) on SWE were recorded. Additionally, 2D elastic images were classified into four color patterns (red, blue, green and yellow). The area under the receiver operating characteristic (AUROC) curve analysis was performed to evaluate the diagnostic performance of SWE in differentiating tumor versus normal liver.

Results: There were statistically significant differences between tumor rim and tumor core (mean tumor rim SWEM = 32.69, SD = 18.64 KPa, mean tumor core SWEM = 13.21, SD = 2.73 KPa, p = 0.001), total tumor and liver (mean liver = 7.96, SD = 1.28 KPa, p<0.0001), tumor core and liver (p<0.001). Compared with other quantitative SWE parameters, mean values expressed in KPa had the highest AUROC value (AUROC = 0.90), with corresponding cut-off value of 17.8 KPa for differentiating tumor from liver, sensitivity of 85.1%, specificity of 96.6%, accuracy of 94.2%, PPV of 86.9%, and NPV of 96.2%.

Conclusions: SWE with elastic modulus values can successfully differentiate tumor rim vs. tumor core vs. normal liver in the rabbit model of liver cancer.

Abstract No. 479

Evaluating the frequency and severity of ovarian venous congestion on adult female computed tomography (CT)

J. Hoffmann¹, D. Szaflarski², E. Sosner3, T. French2, S. Sayegh4, D. Katz4; ¹NYU Winthrop Hospital, Garden City, NY; ²Winthrop University Hospital, Mineola, NY; ³N/A, New York, NY; ⁴Winthrop-University Hospital, Mineola, NY

Purpose: Abdomen and pelvic CT is often utilized to evaluate pain in women. While chronic pelvic pain is relatively common, no large or medium-sized studies have been conducted to our knowledge to evaluate the frequency and severity of ovarian vein dilatation, either incidentally discovered or when scanned specifically for unexplained pain. The purpose of our study was therefore to analyze a large number of consecutive body CT scans in adult women to determine gonadal varicosity incidence and severity.

Materials: An IRB approved, single-institution retrospective analysis of 1,042 consecutive body CT scans in women ages 25 to 65 was performed. Scans were evaluated for the presence and severity of uni- or bilateral ovarian vein dilatation (transverse
measurement at the level of the iliac crests), association with “nutcracker” anatomy, and correlation with the history provided on the requisition. We used binomial proportion with 95% CI of gonadal vein dilatation in this population, including analysis of right-side only, left-side only and bilateral dilatation. All analyses were performed using SAS 9.4.5.

**Results:** Of the 1,042 scans reviewed, 9.3% had bilateral dilatation (95% CI 7.5%-11.1%), 2.8% had left side only dilatation (95% CI 1.8%-3.8%), and 1.7% had right-side only dilatation (95% CI 0.9%-2.5%), for a total of 144 positive cases (13.8%). Of the positive scans, 97 were bilateral (67.4%), 29 were left-side only (20.1%), and 18 were right-side only (12.5%). 18 patients had nutcracker-type left renal vein compression (14.3% of scans with dilated left or bilateral ovarian veins, 1.7% of all scans). In positive scans, the median right and left side dilatation were both 7mm (range, 5mm to 14mm). Based on our findings, the dilatation grading scheme developed was mild (<6mm), moderate (6-8mm), and severe (>8mm), with moderate including the middle 33% of cases.

**Conclusions:** Dilated ovarian veins were found in 13.8% of 1,042 consecutive abdominal and pelvic CT scans. Moderate gonadal vein dilatation is defined as a diameter of 6 to 8mm at the iliac crests. Additional studies are needed to determine the clinical relevance of the degree of dilatation.

---

**Abstract No. 480**

**Using principal component analysis to quantify hepatocellular carcinoma angiographic enhancement (tumor blush) after transarterial chemoembolization: proof of concept**  
J. Miller¹, R. Ramaswamy², O. Akinwande²;  
¹Washington University School of Medicine, St. Louis, MO; ²Department of Interventional Radiology, Washington University School of Medicine, St. Louis, MO

**Purpose:** To use principal component analysis (PCA) to improve conspicuity and quantify degree of hepatocellular carcinoma (HCC) angiographic enhancement (tumor blush) after transarterial chemoembolization (TACE). To also correlate the degree of enhancement with response.

**Materials:** Twenty-seven primary HCC tumors in 25 patients (18 men, 7 women; mean age 66 y ± 9) were analyzed. We used dynamic contrast-enhanced image analysis, combined with PCA, to create images of tumor and liver vasculature from TACE angiograms. A time series of images was condensed into a single image that represented both the spatial information and the contrast media dynamics. We analyzed our PCA-generated vasculature images to compare the contrast media intensity within the vascular system of the tumor to that of the surrounding liver. The tumor-to-liver intensity ratio over the time of the injection was used to determine the relative vascular enhancement of the tumor. Student t-test and Pearson correlation statistic were performed.

**Results:** Using PCA-generated images, the tumor enhancement was more conspicuous compared to any single fluoroscopic image. Further, we were able to quantify the degree of perfusion in a predictable way. Each tumor was assigned a vascular enhancement value (VEV). The relative vascular enhancement of the tumor was not a predictor of tumor response to TACE per the modified Response Evaluation Criteria in Solid Tumors (mRECIST) at 1 month; however, when the relative vascular enhancement was normalized by the tumor pretreatment length to create a normalized VEV, there was a trend. Tumors that responded to treatment (N = 12), had a statistically higher normalized VEV compared to the non-responders (N = 15), with a mean value of 0.96 ± 0.455 vs. 0.57 ± 0.309, (p = 0.013). When examining each response group separately, there was a positive correlation between tumor response and normalized vascular enhancement (r = 0.52, p = 0.006).

**Conclusions:** PCA provides better tumor conspicuity and an ability to quantify degree of enhancement/perfusion from routine angiographic images during TACE. Additionally, this method may allow for the prediction of tumor therapeutic response to TACE.

---

**Abstract No. 481**

**Visualization performance of neuroangiographic systems using a novel calibrated dynamic vascular phantom: a comparison of Philips Allura and Siemens Artis Zeego**  
J. Mason¹, A. Beardsley¹, C. Dodge², S. Hilsenbeck³, G. Bennörf¹; ¹Baylor College of Medicine, Houston, TX; ²Texas Children’s Hospital, Houston, TX

**Purpose:** Previous work comparing visualization performance of current state-of-the-art neuroangiographic systems using a calibrated model proved feasible but lacked dose rate monitoring and simulation of tissue attenuation. In the current study, imaging was performed using optimized dose rates and an improved phantom version that simulates tissue attenuation allowing for more accurate quantification and comparisons of two state-of-the-art angiographic systems by measuring signal-to-noise ratios (SNRs).

**Materials:** Experimental setup was matched on both angiographic systems and kV settings were chosen to ensure identical dose rates. The vascular phantom consisted of a continuous tubing simulating small vessels with step-wise reduced inside diameters from 500 to 100 microns encased in 16 cm of PMMA to simulate tissue attenuation. Omnipaque 300 was injected into the phantom and images were obtained using a “blank road map” setting. 2D plot profiles were extracted from the DICOM pixel data using IMAGEJ. MATLAB was then used to automatically calculate the area under the curve on the 2D plot profiles, which were used to generate SNRs.

**Results:** The Artis Zeego system demonstrated superior SNRs compared to the Phillips Allura system when imaging “small vessels” ranging from 250 to 400 microns. There was no significant difference at 100, 175 or 500 microns. However, there was a trend towards better performance of the Artis Zeego system at 175 and 500 microns. Dose rate for both systems was 17 mGy/min.

**Conclusions:** This study demonstrates significant differences between two state-of-the-art neuroangiographic systems, with the Siemens system providing better visualization performance and simulated “small vessels.” This novel method of using a calibrated dynamic phantom proves a promising tool to objectively quantify visualization performance of angiographic systems with potential benefit for both research and clinical practice as part of quality control programs.
Abstract No. 482

Morphological comparison before and after coil embolization of pulmonary arteriovenous malformations on computed tomographs

Y. Baba1, K. Chosa2, H. Mitani3, T. Fuji4, Y. Choi4, K. Awai5; 1Dep of Radiology, Hiroshima University Hospital, Hiroshima, Hiroshima; 2Hiroshima University, Hiroshima, Hiroshima; 3Hiroshima University Hospital, Hiroshima, Hiroshima; 4Seoul national university Boramae Medical Center, Seoul, Dongjak-Gu; 5Hiroshima University Hospital, Hiroshima, Hiroshima

Purpose: To examine morphological changes of pulmonary arteriovenous malformations (PAVMs) before and after coil embolization on computed tomographs (CT).

Materials: Between October 2012 and October 2016, 7 patients (1 male, 6 females, median age 70 years) with 10 PAVMs who improved clinically after coil embolization (CE) of sac PAVMs were enrolled. Pre- and post-CE morphological comparisons included the diameter of the feeders and drainers, the sac volume, and the shrinkage rate the feeding and draining vessels. Computational fluid dynamics (CFD) analysis was performed in 3 patients.

Results: The median follow-up was 360 days (range, 26-1376 days). The average diameter before and after CE of the feeding vessel was 4.4- and 2.8 mm, of the drainage vessel it was 3.7- and 2.5 mm. The average pre- and post-CE sac volume was 211.49 mm³ (median 200.63 mm³). The average shrinkage rate of the feeders and drainers was 37.2% and 33.7%, respectively; the pre- and post-CE diameter of the feeders and drainers was significantly different (p = 0.0001). There was no statistically significant correlation between the sac volume and the shrinkage rate of the feeding (r = -0.3108, p = 0.3820) and the draining vessels (r = 0.09978, p = 0.7839). CFD analysis showed that most of the blood flow from the feeders passed through the PAVM sac. CDF analysis of virtual CE of PAVMs indicated that feeders and drainers were subject to increased wall shear stress (WSS) and that their oscillating shear index (OSI) was increased.

Conclusions: Comparison of pre- and post-CE CT images of PAVMs showed that after the procedure, the diameter of the feeders and drainers was significantly smaller. We think that the absence of a correlation between the sac volume and the shrinkage rate of the feeding and draining vessels is attributable to a post-CE increase in the WSS and OSI.

Abstract No. 483

Noninvasive prediction of hepatic transplant portal vein stenosis

G. Hoots1, M. Vasher2, D. Lababidi3, K. Massis3, B. Zwiebel4; 1Florida Interventional Specialists, Tampa, FL; 2Cincinnati Children’s Hospital Medical Center, Cincinnati, OH; 3N/A, Tampa, FL; 4Radiology Assoc. of Tampa, Inc., Tampa, FL

Purpose: To compare Doppler ultrasound to transhepatic catheter portal venogram in evaluating hepatic transplant main portal vein (MPV) stenosis in order to determine which Doppler ultrasound criteria are often the best for diagnosing MPV stenosis.

Materials: 32 hepatic transplant transhepatic catheter portal venograms were performed due to clinical, biochemical, ultrasound, CT and/or MRI abnormalities. Venograms and pre-venogram Doppler ultrasounds were retrospectively reviewed. Doppler ultrasound criteria of MPV peak velocity, velocity step-up ratio, and change in velocity across the anastomosis were correlated with venography. Our control group consisted of patients who underwent venography without finding of MPV stenosis, as well as 54 randomly chosen patients without suspicion of hepatic transplant MPV stenosis.

Results: MPV stenosis was identified on 25 venograms. Doppler ultrasound detection of MPV stenosis was achieved using the following criteria: velocity step-up ratio threshold of 2.4 (95% sensitive; 92% specific); threshold for change in velocity across the anastomosis of 69 cm/sec (95% sensitive; 72% specific); and threshold for peak velocity of 220 cm/sec (60% sensitive; 95% specific).

Conclusions: Using our Doppler ultrasound criteria, accurate detection of MPV anastomotic stenosis can be reliably diagnosed prior to transhepatic catheter portal venography.

Doppler Ultrasound Criteria for Detecting a Main Portal Vein Anastomotic Narrowing of at Least 50% on Subsequent Portal Catheter Venogram (95% Confidence Interval)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPV peak velocity of 220 cm/sec</td>
<td>0.60</td>
<td>0.95</td>
<td>0.83</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>MPV velocity step-up ratio of 2.4</td>
<td>0.95</td>
<td>0.92</td>
<td>0.90</td>
<td>0.96</td>
<td>0.93</td>
</tr>
<tr>
<td>Change in velocity across the main portal vein anastomosis of 69 cm/sec</td>
<td>0.95</td>
<td>0.72</td>
<td>0.72</td>
<td>0.95</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Abstract No. 484

Angiography unmasking fibromuscular dysplasia in patients with acute renal infarction

E. Gandras1, C. Greben1, D. Ohngemach1, K. Chen2, S. Hong1, L. Mailloux1; 1Florida Interventional Specialists, Tampa, FL; 2North Shore University Hospital, Manhasset, NY; 2Zucker School of Medicine at Hofstra/Northwell, Manhasset, NY

Purpose: Renal infarction may be an overlooked cause of acute flank pain. Cardiogenic embolism is the most common cause. Fibromuscular dysplasia (FMD) is a risk factor for renal infarction; however, the observation of this association in the literature has been limited to case reports and small series. The purpose of this presentation is to demonstrate a rationale for angiography in establishing the diagnosis of FMD in a series of patients who presented with acute renal infarction and underwent angiography.

Materials: We retrospectively reviewed the charts of 27 patients who presented with acute renal infarction and underwent angiography between 1999 and 2017. Renal infarction was initially identified on CT or ultrasound imaging. Follow-up CTA, MRA, duplex ultrasound, and angiography reports and images were reviewed when available for the presence and laterality of renal arterial abnormalities suggesting FMD, such as beading of the main renal artery, aneurysm, or dissection, and for the performance of endovascular intervention.
Results: Angiography unmasked FMD in 17 patients (63%). 11 of these 17 patients (65%) were found to have renal arterial abnormalities on initial cross-sectional imaging. However, 2 of these 11 (18%) were false positives with no findings on angiography. Of the 12 patients with FMD on angiography with available cross-sectional imaging, only 6 (50%) demonstrated arterial abnormalities on initial imaging. FMD was bilateral in 6 patients (35%), 4 of which were initially diagnosed with unilateral renal infarct. Angiography further demonstrated the pattern of FMD: main (35%), branch (18%), or combination (47%). Angiography also revealed dissections and aneurysms associated with FMD in 11 patients (65%). Endovascular intervention was performed on 4 patients (24%), only one of which was performed acutely.

Conclusions: In our case series, renal angiography revealed FMD in 63% of patients presenting with acute renal infarction. Renal angiography is indicated for the diagnosis and potential treatment of fibromuscular dysplasia in patients presenting with acute renal infarction without an embolic source.

Abstract No. 485
Clinical and radiographic determinants of survival in cancer patients with acute pulmonary embolus
M. Patel1, J. Kuban2, C. Wu2, R. Sheth2, S. Yevich2, S. Huang2, S. Sabir2, G. Pismisis2, T. Huynh2, W. Wei2, K. Ahrar2; 1Baylor College of Medicine, Houston, TX; 2MD Anderson Cancer Center, Houston, TX

Purpose: To identify clinical and imaging predictors for survival following the diagnosis of pulmonary embolism in cancer patients.

Materials: A single-institution retrospective review of 174 patients with CT angiogram proven acute pulmonary embolus (PE) from 2014 was performed. Clinical, laboratory and radiographic data was reviewed. Patients were classified as low-risk (LR, n = 74), intermediate-low risk (ILR: right heart strain OR with elevated cardiac biomarker, ie troponins and BNP (CB), n = 78), intermediate-high risk (IHR: right heart strain AND CB, n = 17), and high risk (HR: sustained hypotension < 90 and/or pressor requirement, n = 5). Logistic regression models were used to associate factors with survival at 30 and 90 days.

Results: HR patients had a 30 and 90 day all-cause mortality of 40.0% and 60.0% respectively and were higher than LR patients which were 6.8% and 21.6%. IHR patients had 30 and 90 day all-cause mortality of 41.2% and 53.0% significantly greater than LR patients (p = 0.001 and 0.015). There was not a significant difference in 90-day all-cause mortality between HR and IHR groups (p = 1.0) or between the ILR and LR groups (p = 0.2). RV/LV > 0.9 was found to be significantly associated with 90-day mortality (OR 2.7, p = 0.01), independent of other variables. IVS bowing, presence of active cancer, active cancer therapy, CB elevation, number of lobes involved by PE and the location of PE were not significantly related to survival at 30 or 90 days.

Conclusions: Cancer patients with acute PE without hemodynamic instability and evidence of both right heart dysfunction and CB have similar 30- and 90-day mortality to PE patients who present with hemodynamic instability. Close monitoring is warranted for these patients. Furthermore, right heart strain, as measured on CT RV/LV ratio, is associated with mortality independent of other clinical variables including whether patients are receiving concurrent radiation or chemotherapy. Additional studies are needed to determine if active intervention and relief of right heart strain from acute PE can improve survival in this patient population.

Abstract No. 487
Confirmation of the needle position for dynamic contrast-enhanced MR lymphangiography using us contrast
M. Ponce-Dorrego1, D. Biko2, K. Darge2, G. Nadolski3, M. Itkin4; 1Hospital of the University of Pennsylvania, Philadelphia, PA; 2Children’s Hospital of Philadelphia, Philadelphia, PA; 3University of Pennsylvania, Philadelphia, PA; 4Penn Medicine, Bala Cynwyd, PA

Purpose: The mechanism of traumatic aortic transection usually involves sudden deceleration causing juxtaductal injury at the aortic isthmus secondary to tethering of the arch at this location. Aberrant right subclavian artery (ARSA) is the most common aortic arch variant, with an incidence reported in the literature of 0.5-2.5%. The ARSA typically arises distal to the ostium of the left subclavian artery with a retroesophageal course which causes more distal tethering of the aorta. As such, the pattern of aortic injury in the setting of ARSA is likely to differ from those encountered with a normal arch configuration.

Materials: Retrospective review of all cases of aortic transection in the setting of trauma at a single-center from 2002 to 2017 identified 22 patients. Clinical data was obtained using electronic medical records. Images were reviewed using PACS.

Results: The mechanism of injury was motor vehicle collision in all 22 patients identified with aortic transection in the setting of blunt aortic injury from 2002 to 2017 at a single institution. Surgical repair was performed in 5 patients, 15 underwent percutaneous/hybrid repair, and 2 died without intervention. 20 of 22 patients had normal arch anatomy and the site of injury was at the isthmus. ARSA was present in 2/22 (9%) patients and in both patients the aortic rupture was distal to the ostium of the ARSA. These patients were both managed with aortic endograft placement and either surgical or endovascular right subclavian reperfusion.

Conclusions: The aortic isthmus was injured in all patients with conventional arch anatomy, but both patients with ARSA sustained injury more distally beyond the ostium of the ARSA. We hypothesize that the ARSA variant anatomy alters the pattern of injury on the aorta secondary to differences in biomechanics and deceleration forces. This hypothesis could be further evaluated with data from a consortium of trauma centers. The variant anatomy and differences in injury pattern seen with ARSA have management implications, and we also review the special treatment considerations needed in the setting of ARSA with either surgical bypass or covering and fenestrating the ostium to maintain ARSA perfusion.

Abstract No. 486
A single-center experience with endovascular management of aortic transection: unique features in aberrant right subclavian artery
B. Gardner1, M. Tracci1, J. Angle1, M. Hanley1; 1University of Virginia, Charlottesville, VA

Purpose: The mechanism of traumatic aortic transection usually involves sudden deceleration causing juxtaductal injury at the aortic isthmus secondary to tethering of the arch at this location. Aberrant right subclavian artery (ARSA) is the most common aortic arch variant, with an incidence reported in the literature of 0.5-2.5%. The ARSA typically arises distal to the ostium of the left subclavian artery with a retroesophageal course which causes more distal tethering of the aorta. As such, the pattern of aortic injury in the setting of ARSA is likely to differ from those encountered with a normal arch configuration.

Materials: Retrospective review of all cases of aortic transection in the setting of trauma at a single-center from 2002 to 2017 identified 22 patients. Clinical data was obtained using electronic medical records. Images were reviewed using PACS.

Results: The mechanism of injury was motor vehicle collision in all 22 patients identified with aortic transection in the setting of blunt aortic injury from 2002 to 2017 at a single institution. Surgical repair was performed in 5 patients, 15 underwent percutaneous/hybrid repair, and 2 died without intervention. 20 of 22 patients had normal arch anatomy and the site of injury was at the isthmus. ARSA was present in 2/22 (9%) patients and in both patients the aortic rupture was distal to the ostium of the ARSA. These patients were both managed with aortic endograft placement and either surgical or endovascular right subclavian reperfusion.

Conclusions: The aortic isthmus was injured in all patients with conventional arch anatomy, but both patients with ARSA sustained injury more distally beyond the ostium of the ARSA. We hypothesize that the ARSA variant anatomy alters the pattern of injury on the aorta secondary to differences in biomechanics and deceleration forces. This hypothesis could be further evaluated with data from a consortium of trauma centers. The variant anatomy and differences in injury pattern seen with ARSA have management implications, and we also review the special treatment considerations needed in the setting of ARSA with either surgical bypass or covering and fenestrating the ostium to maintain ARSA perfusion.
Purpose: Successful dynamic contrast-enhanced MR lymphangio- 
graphy (DCMRL) relies on proper position of the needles in the 
inguinal lymph nodes to inject gadolinium based contrast. When 
placed under US guidance in a combined MR-fluoroscopy suite, 
noodle position can be confirmed by fluoroscopic injection of 
iodinated contrast. The objective of this study is to assess the 
feasibility of validating needle position in inguinal lymph nodes 
using intranodal injection of US contrast prior to DCMRL. 

Materials: In 4 female patients, 25G needles were placed in 
bilateral inguinal lymph nodes using US guidance outside the MR 
suite. The confirmation of needle position was performed by 
injecting 0.25 mL of US-contrast mixed with 2.5 mL of lidocaine 
and examining the efferent lymphatic ducts distal to the lymph 
node for contrast enhancement. Patients were then transferred to 
MR suite and DCMRL performed by injecting gadoterate meglu-
mine (0.5 mmol/mL, 0.2 mmol/kg).

Results: In 7 injections, enhancement of the lymph node itself and 
the efferent lymph ducts were demonstrated. In 1 injection, 
extravasation of the contrast outside the lymph node was demon-
strated with no enhancement of the draining lymphatics. In this 
patient, the needle was repositioned and additional injection of the 
US contrast demonstrated enhancement of the efferent lymphatics. 
DCMRL was then performed in all patients with good opaci-
fication of the central lymphatic system confirming the findings 
observed during injection of US contrast. No extravasation of 
gadolinium contrast agent was observed.

Conclusions: Injection of US contrast for confirmation of the 
position of needles inside inguinal lymph nodes is a safe and 
effective technique. This technique can serve as a substitute for 
fluoroscopic confirmation of needle position allowing performance of the DCMRL on any MR machine.

Abstract No. 488

Overall survival and survival after second primary in thermal ablation, resection, and 
transplantation in patients with cured primary and subsequent 
second primary hepatocellular carcinoma, a SEER study

S. Arndt1, P. Gilbert1, T. Sandow2, D. Kay1, D. DeVun1, D. Goldman3, J. Gimenez1, V. Ramalingam1; 1Ochsner 
Clinic Foundation, New Orleans, LA; 2Medstar 
Georgetown University Hospital, Washington D.C.; 3University of Queensland - Ochsner Clinical School, 
New Orleans, LA

Purpose: To compare overall survival and survival after develop-
ment of a second primary in patients with cured initial primary 
hepatocellular carcinoma (HCC) treated with surgery, trans-
plantation, and thermal ablation (TA) in the Surveillance, Epide-
miology, and End Results (SEER) cohort.

Materials: SEER cohort cases of confirmed initial primary HCC 
and second primary HCC after initial treatment diagnosed 2004-
2014 were evaluated. 331 tumors in 165 patients were included in 
this study, after excluding patients with undefined treatment course. 
Shapiro Wilk testing revealed non-normal distribution of overall 
survival and survival after second primary occurrence (p<.001), so 
Wilcoxon and Kruskall Wallis testing were used to assess survival 
based on continuous and ordinal variables. For categorical vari-
bles, Fischer’s exact test was used. Kaplan Meier curves were 
generated for survival after treatment of initial primary HCC, and 
for second primary HCC after primary treatment with surgery, 
primary treatment with RFA, and primary treatment with transplant.

Results: No difference in overall survival was found between 
patients with initial primary treatment with TA, surgery or trans-
plant as primary treatment (P = 0.186). Similarly, no differences in 
survival were found between TA, surgery or transplant for second 
primary HCC after TA as initial primary treatment (p = 0.137), 
after surgery as initial primary treatment (P = 0.167), or after 
transplant as initial primary treatment (p = 0.863). Propensity score 
matching was performed to control for tumor size for initial pri-
mary HCC and second primary HCC, and no significant difference in 
overall survival between treatments was found for primary HCC 
(P = 0.596), or second primary HCC (p = 0.074).

Conclusions: As prediction of posttransplant or postprimary 
treatment development of second primary HCC improves, com-
parison of long-term and complex treatment courses is needed. 
Non-inferiority of TA as initial or subsequent therapy in compar-
ison to surgery and transplant was demonstrated in patients who 
developed second primary HCC treated with curative therapy for 
initial and subsequent second primary HCC drawn for the SEER 
database.

Evaluation of microwave ablation zone temperature following administration of a novel 
thermal accelerant agent in swine: An MR thermometry study

A. Maxwell1, W. Park1, E. Walsh2, G. Baird1, M. Primmer1, K. Lombardo1, S. Lu1, D. Dupuy1; 1The 
Warren Alpert Medical School of Brown University, Providence, RI; 2Brown University, Providence, RI

Purpose: To evaluate the effects of a novel thermal accelerant 
(TA) agent on microwave ablation zone temperature using real-
time magnetic resonance thermometry (MRT) in porcine liver and 
skeletal muscle.

Materials: This study was performed following IACUC approval. 
Castrated adult male domestic swine underwent microwave abla-
tion under general endotracheal anesthesia. The Surlate system 
(Vision Medical, Santa Clara, CA) was used for all ablation 
treatments at a generator power of 100W and a frequency of 2,450 
MHz for 5 or 10 minutes. Treatments were performed percutane-
ously with and without injection of 2-3 mL TA via a 5 Fr catheter at a 
distance of approximately 1.5 cm from the ablation antenna 
within normal liver and skeletal muscle. Separately, ablations were 
also performed in ex vivo whole livers. Real-time MRT was con-
ducted on a 3.0 Tesla scanner (Siemens, Erlangen, DE) using a 
multigradient echo sequence with fat suppression and respiratory 
gating. Frequency-derived thermal maps were generated according 
to the slope of the phase vs. TE line on a per-pixel basis with 
temperature change calculated from the known temperature 
development of the water proton chemical shift. Ablation zone 
temperature change was quantified according to the volume of 
tissue that achieved a cytotoxic temperature greater than or equal to 
60°C (V60). Data were analyzed with SAS/GLIMMIX using 
generalized mixed modeling and sandwich estimation assuming a 
lognormal distribution. Statistical significance was set at α = 0.05.
Results: A total of 34 ablations were performed (in vivo liver: 8 TA, 8 control; ex vivo liver: 7 TA, 5 control; in vivo muscle: 3 TA, 3 control). Mean V60 was significantly higher among TA ablations in both the in vivo and ex vivo liver groups when compared with controls (27.6 cm³ vs. 18.6 cm³ and 63.1 cm³ vs. 43.7 cm³, respectively; p < 0.01). A trend toward significance was observed in the TA muscle ablation group (42.0 cm³ vs. 28.8 cm³, p = 0.07). In all three experimental conditions, an approximately 50% increase in V60 was seen with TA use.

Conclusions: The use of thermal accelerant results in higher ablation zone temperatures as assessed by MRT. Further investigations in animal and human subjects are planned.

Abstract No. 490

OPuS One trial: A postmarket study to evaluate the effectiveness of the OsteoCool™ Radiofrequency (RF) Ablation System

S. Bagla1, S. Bolstrom2, H. Berrier2, T. Brelje2; 1Vascular Institute of Virginia, McLean, VA; 2Medtronic, Minneapolis, MN

Purpose: The purpose of this prospective, multi-center, non-randomized study is to evaluate the effectiveness of Medtronic’s OsteoCool™ Radiofrequency (RF) Ablation System. The goal is to collect real-world outcomes among a cohort of patients in the United States (US), Europe (EUR) and Canada (CAN). The primary objective is to demonstrate an improvement post-RF ablation in worst pain score at the target treatment site in the past 24 hours for subjects with metastatic lesions in only the thoracic and/or lumbar vertebral body(ies). To date, no study has evaluated long-term clinical outcomes among patients with painful bone metastases or bone lesions after receiving RF ablation with the OsteoCool™ RF Ablation System.

Materials: The study will evaluate up to 250 subjects in the US, EUR and CAN with metastatic malignant lesions in a vertebral body, painful metastatic lesions involving bone (in the US, patients with metastatic lesions involving the bone must have failed or were not candidates for standard therapy), and in EUR and CAN, benign bone tumors such as osteoid osteoma who receive treatment with the OsteoCool™ RF Ablation System. Patients will be evaluated prior to the RF ablation procedure, during the procedure, prior to hospital discharge, 3 days, 1 week, and 1-, 3-, 6-, and 12-months post procedure. Patient outcomes, such as pain relief, quality of life and function, will be evaluated using validated assessment measures. Patient demographics and disease characteristics will be collected. Additionally, the study will collect all serious adverse events and all device, procedure and/or therapy related adverse events and device deficiencies.

Results: Site qualification and activation is underway. First patient enrollment is expected in September 2017. Patient demographics, such as number of enrolled subjects, age and gender, and disease characteristics (e.g., primary cancer type, location and characteristics of metastases and/or tumor site) will be presented.

Conclusions: Demographic information and disease characteristics collected from this clinical trial will help to characterize the type of patient being treated with RF ablation in clinical practice today.

Abstract No. 491

Simultaneous bipedicular radiofrequency ablation for local tumor control of vertebral metastases

R. Chang1, T. Hillen2, A. Wallace2, A. Tomasian3, J. Jennings2, 1Washington University School of Medicine, St. Louis, MO; 2Mallinckrodt Institute of Radiology, St. Louis, MO; 3University of Southern California, Los Angeles, CA

Purpose: To evaluate the safety and effectiveness of simultaneous bipedicular radiofrequency ablation (RFA) for local tumor control of vertebral metastases.

Materials: Thirty-five spinal lesions in 29 patients were treated, of which 31/35 (89%) and 19/35 (54%) involved the posterior vertebral body and pedicle, respectively. Sixty percent of the lesions involved 75% or more of the vertebral body. Lesions were treated with two articulating, navigational bipolar RFA probes (STAR, Merit) simultaneously to allow more confluent overlapping ablation zone to encompass as much vertebral body volume as possible while minimizing risk of thermal injury and impedance by using variable wattage (3, 5, 7.5, or 10 watts). Mean total ablation times per probe were 18.3 minutes (range, 9.9–29.3) with overlapping ablations zones performed anteriorly, posteriorly, and within the pedicle. Postablation cementoplasty was performed in all cases via the same introducer cannula. Complications were assessed based on the Society of Interventional Radiology classification. Postprocedure local tumor control was defined as the absence of residual enhancement on contrast-enhanced MRI, radiotracer activity on PET, or stability of osteolysis on CT.

Results: All lesions were successfully ablated without any complications or thermal injury. Of the 28 lesions with postprocedure imaging, local tumor control was observed in 96% (27/28) of cases at a mean follow-up of 12.7 weeks (range, 1–48). Retraction of epidural tumor was seen in 3 cases.

Conclusions: Simultaneous bipedicular RFA is safe and effective in the treatment of vertebral metastases, including those involving the posterior vertebral body and pedicle. This novel technique supports the stereotactic spine radiation surgery paradigm to treat the entire vertebral body and pedicles (i.e. clinical target volume) to account for microscopic disease and marginal failures for better local tumor control rates and more durable pain relief.

Abstract No. 492

Feasibility and effectiveness of thermal ablation therapy of renal cell carcinoma in patients with a solitary kidney

Y. Sugino1, A. Nakatsuka2, T. Yamanaka3, M. Takafuji4, H. Sakuma5, N. Matsushita6; 1Mie university hospital, Tsu, Japan; 2Mie University School of Medicine, Tsu, Mie Pref; 3N/A, Tsu, Japan; 4Mie University Hospital, Tsu, Mie; 5Mie university hospital, Tsu, Mie

Purpose: To retrospectively evaluate the feasibility and effectiveness of thermal ablation therapy (radio frequency ablation; RFA, cryoablation; CA) in patients with solitary kidney for the treatment of renal cell carcinoma (RCC).
Percutaneous endovascular radiofrequency ablation for portal vein tumor thrombosis in patients with hepatocellular carcinoma: a single-center experience

W. Ding¹, W. Wang¹; ¹Wuxi People’s Hospital, Wuxi, Jiangsu

Purpose: Percutaneous endovascular radiofrequency ablation (RFA) has been validated as a novel safe and feasible technique for portal vein tumor thrombosis (PVTT) in patients with hepatocellular carcinoma (HCC). The purpose of this study was to evaluate the preliminary efficacy of RFA in such challenging scenario at our medical center.

Materials: This retrospective study included all patients with PVTT caused by HCC who underwent percutaneous endovascular RFA between April 2014 and March 2017 at a single center. Gastroesophageal variceal embolization and/or stent placement was conducted if needed during the intravascular operation. Transarterial chemoembolization (TACE) was performed after the endovascular RFA procedure in terms of clinical requirement. The main clinical records we collected were baseline characteristics, procedural details, postoperative biochemical changes, procedure-related complications, portal patency and overall survival. Follow-up was carried out every 2 weeks for the first month postoperatively, and then monthly.

Results: 10 patients (mean age, 57.4 years; range, 41-75 years) enrolled in the study underwent 10 successful endovascular RFA sessions, once per person. The procedures of 3 gastroesophageal variceal embolization and 3 stent implantation were completed in 5 patients concurrently, with 1 patient of both. No technique-specific complications such as hemorrhage, vessel perforation or infection were observed. During the follow-up period after endovascular RFA procedure, 28 cycles of TACE were performed with a mean of 2.8 cycles per patient. Median patency period of the involved portal vein was 127 days (range, 39.3–214.7 days). Median overall survival was 190 days (range, 120.3–259.7 days). All of the death was attributed to tumour burden or progression (100%, 9/9).

Conclusions: Percutaneous endovascular RFA may be an alternative therapeutic option for the management of PVTT in patients with HCC and warrants further larger prospective investigation to assess the clinical efficacy with this recanalization technique. Meanwhile, the control of the tumour burden or progression via various available therapies is essential.

Microwave ablation zone observations in a large series with recommendations for adjustments

T. Froud¹, P. Mohan², S. Venkat³, R. Lencioni³, G. Narayanan⁴; ¹University of Miami, Miami, FL; ²University of Miami Miller School of Medicine, Miami, FL; ³University of Miami Miller School of Medicine, Miami, FL; ⁴University of Miami- Miller School of Medicine, Miramar, FL

Purpose: Microwave ablation (MWA) is and established technology that has recently been applied to interventional oncology. Ablations rely on a certain power (watts) for a certain time (minutes/seconds). Charts provided by manufacturers are produced using ex-vivo bovine liver at 20°C. Results in living patients do not conform with the charts. This retrospective analysis of 121 ablation zones evaluates differences and suggests how to adjust parameters in clinical practice.

Materials: 73 patients underwent MWA of 136 liver lesions in 85 procedures. Lesions measured 2.7 × 2.3 × 2.4 cm (SDep 1.4 × 1.2 × 1.4 cm), HCC n = 91, Cholangio n = 6, metastasis n = 39. Each lesion was treated with a single ablation. Manufacturer anticipated ablation zone and actual ablation zone measured within 24 hours on venous phase CECT images were compared. Power/time values on manufacturer charts compared to operator selected (standard (S) vs non-standard (NS) ablations); HCC vs other lesion pathology sought to assess the effect of a presumed fibrotic liver parenchyma.

Results: Overall mean anticipated ablation zone dimensions were 4.8 ± 3.7 × 3.7 cm (SDep 1.1 ± 0.8 × 0.8 cm) compared to actual 4.1 ± 3.0 × 3.2 cm (SDep 1.2 ± 0.9 × 1.1 cm) (n = 121). Differences in individual dimensions were highly significant ttest p < 0.0005. Zone volumes using volume of an oval, were 37.5 ± 25 cm³ vs 24.6 ± 24.1 cm³ (p < 0.0001) mean 68% of predicted (range, 8.5–217%). In 107/136 lesions the zone was mean 50.4 ± 23.1% smaller, in 29/136 mean 133.6 ± 27.3% larger. In S ablations, zones were mean 64.8 ± 41.8% predicted versus 78.7 ± 40.5% predicted in NS ablations. HCC ablation zones were mean 63.5 ± 40.1% predicted versus 67.2 ± 46.1% in non-cirrhotic livers.

Conclusions: In approximately 3/4 ablations the actual ablation zone is significantly smaller than suggested based on manufacturer charts. Individualizing power/time values may improve this by inadvertent underestimation of anticipated ablation zones. Cirrhosis may exacerbate discrepancies. Larger zones did not increase complication rates. Planning of larger ablation zones is recommended to improve outcomes.
Non-invasive liver tumor ablation using histotripsy in an in vivo subcutaneous murine hepatocellular carcinoma model

T. Worlikar1, E. Vlaisavljevich2, T. Gerhardson1, S. Wan3, S. Kuruvilla1, K. Ives1, J. Greve1, T. Hall4, T. Welling2, F. Lee5, Z. Xu6, 1University of Michigan, Ann Arbor, MI; 2Virginia Tech University, Blacksburg, VA; 3NYU Langone Health, New York, NY; 4University of Wisconsin, Madison, WI

Purpose: Histotripsy is a non-thermal, non-invasive ultrasound (US) ablation method that fractionates tissue through the precise control of acoustic cavitation guided by real-time US imaging. Histotripsy has the potential to improve treatment consistency and precision compared to thermal-based ablation methods. This study evaluates the feasibility and tumor volume reduction effects of histotripsy for liver cancer ablation in an in vivo murine HCC model.

Materials: Subcutaneous xenograft tumors were generated by injecting human HCC Hep3B cells into 14 NSG mice (acute group A: treated n = 9, control n = 1 and chronic group B: treated n = 2, control n = 2) and 6 NOD-SCID mice (chronic group C: treated n = 6). Once tumors reached >5 mm, mice were treated by histotripsy using a custom built 1 MHz histotripsy transducer attached to a motorized positioner guided by US imaging system. 1-2 cycle histotripsy pulses at 100 Hz PRF (p > 30 MPa) were applied to the tumor volume. MRI was performed pre- and posttreatment to assess tumor ablation. Group A was sacrificed within 3 days post treatment. Groups B and C were monitored weekly using caliper measurements and MRI for 3 months or until tumors reached ~1.8 cm. Tumor, brain and lung tissues were harvested for histology.

Results: Histotripsy-generated cavitation cloud and the treated region were visible on US imaging enabling real-time feedback. In group A, histopathology showed that the targeted region was completely fractionated into acellular debris with a sharp boundary. In groups B and C, MRI revealed effective tumor volume reduction post treatment as the homogenate and edema were resorbed within 3 weeks. However, as the subcutaneous tumor does not allow sufficient treatment margin, residual viable tumor cells developed into tumor regrowth at 3-9 weeks after treatment. Treated mice in group B survived 2-3 times longer than the control mice and showed no signs of metastasis in the lung and brain. At the time of submission, group C mice are being monitored until study endpoint.

Conclusions: This study demonstrates the potential of histotripsy for non-invasive liver tumor ablation. Future work will study the biological response in immune competent orthotopic liver tumor models.

Renal tumor cryoablation with cauterization capable probes: 3-year patient safety experience at a single institution

A. Mai1, M. Mathew2, A. Niekamp3, J. Low4, R. Zvavanjanja5, 1University of Texas Health Science Center at Houston, Houston, TX; 2University of Texas Houston, Houston, TX; 3University of Texas at Houston, Houston, TX; 4MD Anderson Cancer Center, Houston, TX; 5University of Texas at Houston, Houston, TX

Purpose: Percutaneous renal tumor cryoablation is an established minimally invasive treatment therapy. It is however notorious for higher risk of serious bleeding when compared to other thermal ablative modalities. This thought to be due to use of multiple probes which are often large and/or ice ball fracture. In 2014 the FDA approved marketing of cryoprobes with cauterization technology for therapeutic intervention in the treatment of complex tumor geometries.
capabilities. The aim of this study was to review our 3-year patient safety experience with the new cautery capable cryoprobes.

**Materials:*** We retrospectively reviewed the imaging and electronic medical records of all consecutive percutaneous renal cryoablations performed in our institution from June 2014 to September 2017. Cryoablations were performed by a single operator using two freeze thaw cycles per manufacturer recommendations. Renal mass biopsies were performed at the time just prior to the cryoablation. We reviewed the tumor size, location, number and size of cryoprobes used, perinephric hematoma, major bleeding requiring resuscitation or embolization and acute or delayed collecting system injury.

**Results:** There were 43 consecutive patients with 44 renal tumors treated during this period. Tumor size ranged from 1.4 – 4.5 cm and 8 patients had hilar tumors. Biopsies were safely performed in all but 5 patients due to risk of bleeding/tumor size/location. The median number of cryoprobes used per lesion was 3 (range, 2-5). Post cryoablation cautery time per needle was 3 mins. There were no incidences of large perinephric hematoma or bleeding that required fluid/resuscitation, embolization or extended hospital stay. Small post biopsy hematomas were observed in 8 patients. There were no incidences of urine leaks acutely or on follow-up.

**Conclusions:** Our 3-year renal cryoablation experience with the cautery capable cryoprobes suggests they are safe with no serious bleeding complications or collecting system fistulas during the study period. We are now more comfortable tackling traditionally higher bleeding risk lesions. Further multicenter studies are required to validate our early experience.

---

**Abstract No. 498**

CT-guided lung mass biopsy: reduced incidence of pneumothorax with tract injection

H. Kocharyan¹, A. Rastegarpour², K. Loveridge³, C. Bailey⁴, A. Sucher⁵, O. Intikhab⁶, S. Kannab-Aida², H. Aoun¹, J. Critchfield⁴, Wayne State University/DMC, Lansing, MI; ²Wayne State University/Detroit Medical Center, Detroit, MI; ³Detroit Medical Center, Detroit, MI; ⁴Wayne State University/Detroit Medical Center, Brighton, MI; ⁵N/A, Berkley, MI; ⁶Wayne State University/Detroit Medical Center, Warren, MI; ⁷Karmanos Cancer Institute, Detroit, MI; ⁸Karmanos Cancer Institute, Troy, MI

**Purpose:** To investigate the pneumothorax rate of CT-guided lung biopsies with and without absorbable collagen solution tract injection post procedure.

**Materials:** This is a retrospective review of 421 consecutive patients who underwent CT-guided lung biopsy between January 2014 and June 2017 by two interventional radiologists with more than 10 years of experience. All patients underwent CT-guided core biopsies utilizing the coaxial technique consisting of a 19-G outer Trocar needle and a 20-gauge core biopsy needle. 148 patients underwent postbiopsy tract collagen (Heliitene) solution injection (BTCI) as the 19-G Trocar needle was removed. This was compared to a control group of 273 patients who underwent the standard biopsy procedure without collagen agent injection. The incidence of pneumothorax on same day post procedural chest X-rays was compared between the two groups. Statistical analysis was performed by chi-square, Fisher exact, t-test, and Mann-Whitney U test (Wilcoxon rank-sum test) where each was appropriate.

**Results:** Pneumothorax was noted in post procedure chest radiographs in 85 patients (20.2%). Sixty-seven patients (24.5%) and 18 patients (12.2%) had a postprocedure in the control group and BTCI group, respectively. Pneumothorax intervention was required in a total of 15 cases, 14 of which were from the control group and only 1 was from the Heliitene group. Both pneumothorax rate and intervention between the two groups was statistically significant (p = 0.003 and p = 0.024, respectively). Nine patients required chest tube placement; 8 were from the control group and 1 was from the Heliitene group. Six Patients had a blood patch, all of which were from the control group. There was no significant difference between the groups in terms of age (p = 0.145), sex (p = 0.828), number of samples taken (p = 0.977) or sub pleural location (p = 0.669). The average distance from pleural wall to biopsy site in the non-subpleural sites was shorter in the Heliitene group which was statistically significant (17.9 vs 22.1; P = 0.044).

**Conclusions:** The use of BTCI after lung mass core biopsy has significant decrease in the pneumothorax rate and patients requiring post-biopsy intervention.

---

**Abstract No. 499**

The use of the transfemoral transcaval core-needle liver biopsy technique for biopsies of hepatic masses

R. Peng¹, C. Shabrang¹, M. Jagust¹, Y. Golowa¹, J. Cynamon¹; ¹Montefiore Medical Center, Albert Einstein College of Medicine, Bronx, NY

**Purpose:** To describe our experience with the use of the transfemoral transcaval (TFTC) core-needle liver biopsy technique in patients with hepatic masses with contraindications to percutaneous liver biopsy or with intrahepatic lesions that abut or are adjacent to the inferior vena cava (IVC).

**Materials:** In patients with contraindications to percutaneous liver biopsies, which include perihpatic ascites, coagulopathy, thrombocytopenia, morbid obesity, an atrophic liver, or in patients with intrahepatic lesions that are either close to or abut the IVC, TFTC is a viable alternative technique. TFTC is a technique where hepatic tissue is directly obtained through the intrahepatic IVC via a femoral venous approach. In this retrospective case series, the medical, surgical, and radiological records of patients who underwent TFTC liver biopsies of hepatic masses at a single institution between September 2015 and June 2017 were reviewed.

**Results:** There were a total of 6 cases of TFTC liver biopsies for hepatic masses from 5 patients. The indications for biopsy via the TFTC technique include 3 cases of perihpatic ascites, 2 cases of coagulopathy and 1 case where the tumor was located in the right hepatic dome adjacent to the IVC and not amenable to percutaneous liver biopsy. Histopathologic diagnoses were successfully made in all 6 cases. One patient underwent two biopsies - the first biopsy demonstrated rare atypical cells in a dense background of fibrous tissue and the second biopsy performed a week later demonstrated adenocarcinoma of pancreaticobiliary origin. There was one potential complication in a patient with a chronic coagulopathy and a known tumor hemorrhage, which may have been aggravated by the biopsy and was treated with embolization.
Conclusions: Increased rate of pneumothorax in underweight patients after CT-guided lung biopsy

S. Hussain1, S. Ansari2, E. Wiggins3; 1Monmouth Medical Center, long branch, NJ; 2Monmouth Medical Center, Long Branch, NJ; 3N/A, Long Branch, NJ

Purpose: Transthoracic lung biopsies are a cornerstone in the management of patients with pulmonary nodules. Data regarding utilization and outcomes are generally limited to retrospective series from high-volume centers. The purpose of this study was to establish population-based measurements for transthoracic lung biopsy procedure complications and their risk factors.

Materials: Using administrative data from all inpatient and outpatient hospital encounters in California (2009-2011), patients undergoing transthoracic lung biopsies were identified. The demographic characteristics of this patient cohort as well as risk factors for complications were analyzed.

Results: A total of 20,780 transthoracic lung biopsy procedures were performed in 19,420 patients. Biopsies were performed across 314 hospitals, though the top quartile hospitals by volume performed 66% of all biopsies, and the top 10% by volume hospitals performed 38% of biopsies (Gini coefficient 0.57). Complication rates were 16.8% (3511/20780) for pneumothorax, 7.4% (1544/20780) for pneumothorax requiring chest tube, and 1.3% (252/20780) for hemorrhage. Age (OR 1.001 [CI 1.0003-1.001]), tobacco use (OR 1.05 [CI 1.03-1.06]), COPD (OR 1.07 [CI 1.06-1.09]), and hypertension (OR 1.01 [CI 1.003-1.03]) were significantly associated with pneumothorax, while tobacco use (OR 1.03 [CI 1.02-1.04]), COPD (OR 1.07 [CI 1.06-1.08]), and hypertension (OR 1.01 [CI 1.00-1.02]) were significantly associated with chest tube placement. Propensity matching demonstrated that high volume centers were associated with lower pneumothorax rates relative to low volume centers (15% vs 17%, P = 0.01).

Conclusions: Transthoracic lung biopsy is a widely utilized procedure with low major complication rates. These population-level estimates should help establish patient and physician expectations as well as societal guidelines for complication rate thresholds.

Abstract No. 500

Single-center retrospective comparison of pneumothorax incidence after fine-needle aspiration versus core biopsy of lung nodules

A. Salem1, A. Sidor2, D. Sridhar1; 1NYU, New York, NY; 2NYU School of Medicine, New York, NY

Purpose: To compare the incidence of pneumothorax after lung nodule biopsy with fine-needle aspiration versus core biopsy alone.

Materials: All CT-guided lung biopsies performed at a university hospital in a single year were identified via chart review. Records were reviewed for patient demographics, nodule location, patient position, biopsy type, presence of pneumothorax on postprocedure CT or follow-up x-ray, and need for chest tube placement. All biopsies were performed via a 19-g coaxial needle with 20-g core device and/or 22-g fine needle. Chi-squared tests were used to examine the association between biopsy method and pneumothorax events. A p value of <0.05 was used to determine statistical significance.

Results: 218 lung nodule biopsies were performed in 215 patients. 46.8% of patients were male, with median age of 67.0 years. Overall, pneumothorax occurred after 39 biopsies (17.9%), and pneumothorax requiring chest tube placement was required in 11 of the 97 patients who underwent FNA with or without core biopsy (25.8%), and in 14 of the 121 patients who underwent core biopsy alone (11.6%). Chest tube placement was required 11 of the 97 patients who underwent FNA with or without core biopsy (11.3%), and in 4 out of 121 patients who underwent core biopsy alone (3.3%).

Comorbidities (%): Current or former tobacco use 38
COPD 24
Chronic hypertension 40
Coagulopathy 3.3

Conclusions: FNA of lung nodules, with or without core biopsy, was associated with a significantly higher incidence of both pneumothorax and chest tube placement compared with core biopsy alone in this series. Routine use of FNA for lung biopsy may increase complication rates.

Abstract No. 501

Population-based analysis of transthoracic lung biopsies: utilization, complications, and predictors of outcomes

M. Khan1, T. Daileda2, S. Sabir1, A. Tam1, S. Gupta1, S. Sheth2, R. Sheth1; 1MD Anderson Cancer Center, Houston, TX; 2University of Texas McGovern School of Medicine, Houston, TX

Purpose: Transthoracic lung biopsies are a cornerstone in the management of patients with pulmonary nodules. Data regarding utilization and outcomes are generally limited to retrospective series from high-volume centers. The purpose of this study was to establish population-based measurements for transthoracic lung biopsy procedure complications and their risk factors.

Materials: Using administrative data from all inpatient and outpatient hospital encounters in California (2009-2011), patients undergoing transthoracic lung biopsies were identified. The demographic characteristics of this patient cohort as well as risk factors for complications were analyzed.

Results: A total of 20,780 transthoracic lung biopsy procedures were performed in 19,420 patients. Biopsies were performed across 314 hospitals, though the top quartile hospitals by volume performed 66% of all biopsies, and the top 10% by volume hospitals performed 38% of biopsies (Gini coefficient 0.57). Complication rates were 16.8% (3511/20780) for pneumothorax, 7.4% (1544/20780) for pneumothorax requiring chest tube, and 1.3% (252/20780) for hemorrhage. Age (OR 1.001 [CI 1.0003-1.001]), tobacco use (OR 1.05 [CI 1.03-1.06]), COPD (OR 1.07 [CI 1.06-1.09]), and hypertension (OR 1.01 [CI 1.003-1.03]) were significantly associated with pneumothorax, while tobacco use (OR 1.03 [CI 1.02-1.04]), COPD (OR 1.07 [CI 1.06-1.08]), and hypertension (OR 1.01 [CI 1.00-1.02]) were significantly associated with chest tube placement. Propensity matching demonstrated that high volume centers were associated with lower pneumothorax rates relative to low volume centers (15% vs 17%, P = 0.01).

Conclusions: Transthoracic lung biopsy is a widely utilized procedure with low major complication rates. These population-level estimates should help establish patient and physician expectations as well as societal guidelines for complication rate thresholds.

Biopsy procedures 20,780
Patients (n) 19,420
Gender (M/F) 10,246/9174
Age (median in years) 70
Comorbidities (%): Current or former tobacco use 38
COPD 24
Chronic hypertension 40
Coagulopathy 3.3
Race (%): White 68
Black 6.8
Hispanic 12.8
Purpose: Identify the influence of body mass index on rates of clinically significant pneumothorax after CT-guided lung nodule biopsy requiring additional management.

Materials: Retrospective analysis of 98 CT-guided lung nodule biopsies was performed to evaluate for development of clinically significant pneumothorax requiring chest tube placement. The procedures were performed by two experienced interventional radiologists using standardized, outpatient protocol for CT-guided lung biopsy. The patients were categorized by body mass index (BMI) as follows: overweight. Statistical analysis was performed using Chi-square analysis, Fisher’s Exact test and linear regression analysis to determine significance.

Results: Based on the standard BMI scale, 75% of underweight patients suffered a pneumothorax requiring chest tube placement. Four out of 34 normal-weight patients and 4 out of 40 overweight patients experienced a pneumothorax. None of the twenty obese patients developed a pneumothorax. Significance was determined at a level <.05. The chi-square value was 21.011, df = 3 with a p-value of 0.0001407. The Fisher’s exact test was used to compare underweight patients to the remainder of the patient population. This also demonstrated a high-level of significance with the two-tailed p values = 0.0028.

Conclusions: Underweight patients are at a higher risk of developing a clinically significant pneumothorax after CT-guided lung biopsy. This may be due to technical factors such as a lack of the stabilizing effect of the body habitus in heavier patients. Underweight patients may have more severe confounding disease processes such as COPD. Patient’s capacity to control respiration may also be altered in these populations adding to the complexity of the procedure and increasing the complication rate. Significant care and peri-procedural caution must be exercised in the underweight patient. Perhaps use of pleural closure devices should be considered in high-risk patients.

Abstract No. 503

Image-guided bone marrow biopsies: pathological comparison of marrow specimen quality obtained using a Mallet versus without

R. Zvavanjanja1, S. Mauzo2, N. Golardi1, R. Zhang1, A. Baxter2, N. Nguyen1, C. Lei2; 1University of Texas Health Science Center at Houston, Houston, TX; 2The Ohio State University, Columbus, OH; 3University of Texas Health Science Center at Houston, Houston, TX; 4University of Texas Health Science Center at Houston, Houston, TX

Purpose: Bone marrow trephine core biopsies can be obtained with the use of a mallet or without. Anecdotal information from our pathologists suggested mallet obtained samples appeared to have more artifacts. The purpose of this study was to objectively investigate this concern raised by our pathologists.

Materials: We performed a double-blinded, retrospective review of bone marrow biopsies collected by the interventional radiology department at our institution between January and June 2015. Routine bone marrow core biopsy slides were reviewed. The presence of crush artifact, specimen fragmentation, and aspiration artifact, as well as the presence of osteopenia and an overall grade of specimen adequacy, was recorded for each specimen.

Results: There were 93 bone marrow biopsy specimens collected during this period. A sterile mallet was used during the bone marrow biopsy procedure in 29 cases. Use of a mallet was significantly associated with the presence of suboptimal or inadequate specimen quality of bone marrow core biopsy (p<0.005) and was independently associated with severe specimen fragmentation (2+) (p<0.0001). There was no statistically significant association between length of the core and use of a mallet.

Conclusions: Use of a mallet during bone marrow core biopsy collection is significantly associated with morphologic distortion in the form of severe specimen fragmentation and negatively affects specimen adequacy. There is no difference in length of core biopsy as previously thought by using a mallet to advance the needle during the procedure. We recommend that use of this technique should be avoided during specimen collection.

Abstract No. 504

Drug-eluting bead TACE response predicts post liver transplant recurrence in a 6-year cohort

S. Arndt1, T. Sandow1, J. Gimenez1, D. Kay1, P. Gulotta1, D. DeVun1, P. Gilbert1, V. Ramalingam1; 1Ochsner Clinic Foundation, New Orleans, LA

Purpose: To evaluate the role of DEB-TACE response and RETREAT score in a 6-year transplant cohort, along with other variables, noting DEB-TACE is commonly used as a bridge to transplant but full evaluation of DEB TACE response and RETREAT score has not been performed.

Materials: Retrospective analysis of transplanted patients with HCC treated exclusively with DEB-TACE was performed. 95 patients were identified and after excluding 4 patients with transplant mortality and 6 patients without available follow-up data. 885 patients exhibited post-transplant recurrence. One-month cross-sectional contrast-enhanced imaging was used to evaluate DEB TACE response. Effect screening across 22 variables of interest based on literature review identified 4 candidate variables, final treatment response prior to transplant (FTR), RETREAT score, treatment cycles, and treatment number. Analysis of naive, time weighted, and propensity score matched cohorts was performed. Internal validation with feature selection was performed with bootstrap resampling.

Results: Median follow-up time was 786 days posttransplant. Univariate analysis shows significance of all candidate variables, p = 0.0006 for FTR, p = 0.0127 for treatment cycles, p = 0.0192 for treatment number, p = 0.0487 for RETREAT. Multivariate analysis of unweighted data showed FTR p = 0.0052 with odds ratio (OR) of 58.09, total treatment number p = 0.0067 and OR of 3.04. RETREAT was not significant in multivariate analysis with p = 0.41. Propensity score matched cohorts controlling for RETREAT and separately for FTR with acceptable standardized differences of 0.1 showed p = 0.0481 for final treatment response, and p = 0.0595 for RETREAT score. Similar results for time weighted analysis were seen noting increased weight given to RETREAT score. Validation of prediction using only preprocedural data was also performed and produced a C-statistic of 0.876.

Conclusions: DEB-TACE response is a powerful predictor of posttransplant recurrence in this 6-year cohort of transplant.
Abstract No. 505

Comparison of efficacy and safety between drug-eluting beads transarterial chemoembolization and conventional transarterial chemoembolization in unresectable hepatocellular carcinoma patients: a retrospective cohort study

C. Li¹, J. Zhang¹, W. Hu¹; ¹Department of Intervention, The First Affiliated Hospital of Wenzhou Medical University, Wenzhou, Zhejiang Province

Purpose: To investigate the efficacy and safety of drug-eluting beads transarterial chemoembolization (DEB-TACE) in patients with unresectable hepatocellular carcinoma (HCC) compared with conventional transarterial chemoembolization (cTACE) and prognostic factors for efficacy.

Materials: 64 HCC patients were analyzed in this retrospective cohort study, among which 36 patients received DEB-TACE and 28 received cTACE. Treatment response was assessed by CT/MRI according to mRECIST criteria, and PFS was evaluated.

Results: No difference was observed regarding CR, PR, SD, PD, ORR and DCR at 3 months post treatment (all P > 0.05) between DEB-TACE and cTACE groups. Although the ORR (P = 0.020) and DCR (P = 0.047) were notably increased in DEB-TACE group compared with cTACE group. And univariate and multivariate logistic regressions revealed that DEB-TACE treatment was independently associated with better ORR at 6 months (P = 0.008). Moreover, the PFS in DEB-TACE group was prolonged compared with cTACE group (P = 0.028), and multivariate Cox’s regression revealed that DEB-TACE treatment was independently correlated with better PFS. In addition, despite that the levels of all laboratory indexes related to liver function worsened at 3 days post operation in two groups, the levels of AST (P = 0.021) and ALT (P = 0.028) at 3 days were notably lower in the DEB-TACE group when compared with cTACE group.

Conclusions: DEB-TACE was superior to cTACE in unresectable HCC patients in terms of increased treatment responses, prolonged PFS and less liver dysfunction.

| Table 1. Treatment Response in DEB-TACE and cTACE Group |
|-----------------|-----------------|-----------------|-----------------|
|                 | DEB-TACE Group  | cTACE Group     | P Value         |
| 3 months after  |                 |                 |                 |
| operation       |                 |                 |                 |
| CR              | 5(13.9)          | 1(3.6)          | 0.219           |
| ORR             | 29(80.6)         | 18(64.3)        | 0.144           |
| DCR             | 34(94.5)         | 24(85.7)        | 0.646           |
| 6 months after  |                 |                 |                 |
| operation       |                 |                 |                 |
| CR              | 3(8.3)           | 0(0.0)          | 0.250           |
| ORR             | 28(77.8)         | 14(50.0)        | 0.020           |
| DCR             | 33(91.7)         | 19(67.9)        | 0.047           |

Abstract No. 506

Neutrophil-to-lymphocyte ratio but not ring enhancement could predict treatment response and new lesion occurrence in patients with hepatocellular carcinoma by drug-eluting beads transarterial chemoembolization

S. Ying¹, X. Zhou¹, S. Gong¹, Z. Peng¹; ¹The First Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang Province

Purpose: To investigate the association of ring enhancement with neutrophil-to-lymphocyte ratio (NLR), and to determinate the predicting values of ring enhancement and NLR for treatment response and occurrence of new lesions in patients with HCC post drug-eluting beads transarterial chemoembolization (DEB-TACE) treatment.

Materials: 65 consecutive HCC patients were enrolled, and all patients received DEB-TACE by CalliSpheres®. And clinical responses were assessed by mRECIST. Ring enhancement was assessed at 4–6 weeks and NLR was assessed within 24 hours post treatment. New lesion occurrence was evaluated at the last follow-up of each patient.

Results: After DEB-TACE treatment, the CR was 18.5% and the ORR was 87.7%. Ring enhancement was observed in 40(62.0%) patients. Additionally, ring enhancement was not correlated with ANC (P = 0.798), LYM (P = 0.776) or NLR (P = 0.782). No difference was found concerning CR (P = 0.686) and ORR (P = 0.474) or new lesion occurrence (P = 0.567) between patients with or without ring enhancement. In addition, the ANC of patients in CR group was markedly lower than that of patients in non-CR group (P = 0.004), and patients with lower NLRs were likely to achieve better CR (P = 0.076) and less new lesion occurrence (P = 0.094). Subgroup analysis showed that patients with multifocal lesions and higher BCLC stage were of worse CR.

Conclusions: NLR but not ring enhancement post treatment could predict the treatment response and new lesion occurrence of patients with HCC treated by DEB-TACE.

| Table 1. Ring enhancement After 4-6 weeks of DEB-TACE Treatment |
|-----------------|-----------------|-----------------|-----------------|
|                 | HCC patients (n = 65) |
| Items           |                 | Ring enhancement |
|                 |                   | Yes (n%)         | No (n%)         |
|                 |                   | 40(62)           | 25(38)          |

Abstract No. 507

Efficacy and safety profile of drug-eluting beads transarterial chemoembolization by CalliSpheres® beads in Chinese hepatocellular carcinoma patients

G. Zhou¹, Y. Zhang¹, T. Zhou¹, T. Zhu¹, J. Sun¹; ¹The First Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang Province

Purpose: This study aimed to investigate the efficacy and safety of drug-eluting beads transarterial chemoembolization...
(DEB-TACE) treatment by CalliSpheres® in Chinese patients with HCC as well as the predicting factors for response.

Materials: 99 patients with HCC were consecutively enrolled in this study. All participants were treated by CalliSpheres® DEB-TACE. Clinical response was evaluated according to mRECIST criteria. Common Terminology Criteria for Adverse Events (CTCAE) was used to assess the adverse events and liver dysfunction during and after the operation.

Results: Post treatment, 16 patients (16.2%) achieved CR and 59 (59.6%) achieved PR, the ORR was 75.8%. Subgroup analysis showed that patients with higher BCLC stage were of worse CR and ORR rates, and no difference of CR and ORR was found between patients with or without cTACE history. Univariate logistic regression analysis displayed that number of nodules >3, higher BCLC stage and previous cTACE were likely to be correlated with worse ORR. As to liver function, CTCAE grades of laboratory indexes for liver function were increased at 1 week compared to baseline and recovered to the baseline grades at 1-3 months post operation. Besides, most of the common adverse events were light and moderate in our study.

Conclusions: In conclusion, DEB-TACE by CalliSpheres® was efficient and well tolerated in Chinese HCC patients, and BCLC stage, number of nodules and cTACE history might be served as predictive factors for treatment response.

Table 1. Clinical Response of DEB-TACE Treatment in All Patients

<table>
<thead>
<tr>
<th>Parameters</th>
<th>n(%)</th>
<th>n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR (n/%)</td>
<td>16(16.2)</td>
<td>48(25.1)</td>
</tr>
<tr>
<td>PR (n/%)</td>
<td>59(59.6)</td>
<td>90(49.2)</td>
</tr>
<tr>
<td>ORR (n/%)</td>
<td>75(75.8)</td>
<td>136(74.3)</td>
</tr>
<tr>
<td>SD (n/%)</td>
<td>10(10.1)</td>
<td>17(9.3)</td>
</tr>
<tr>
<td>PD (n/%)</td>
<td>14(14.1)</td>
<td>30(16.4)</td>
</tr>
</tbody>
</table>

Abstract No. 508

Comprehensive analysis of factors affecting clinical response and short-term survival to drug-eluting bead transarterial chemoembolization for treatment in patients with liver cancer
X. Wu¹, H. Hu¹; ¹Sir Run Run Shaw Hospital, Zhejiang University College of Medicine, Hangzhou, Zhejiang Province

Purpose: This study was aimed to investigate the clinical response and short-term survival and further explored the comprehensive factors in predicting clinical outcomes in liver cancer patients treated by drug-eluting beads transarterial chemoembolization (DEB-TACE).

Materials: 49 liver cancer patients received DEB-TACE treatment were consecutively enrolled in this cohort study. Demographic features, medical histories, clinicopathological properties, biochemical indexes, previous treatments, chemoembolization regimens were recorded. And clinical response was assessed by mRECIST and OS was calculated.

Results: 10 patients (20.4%) achieved CR and 31 patients (63.3%) achieved PR after DEB-TACE treatment, with ORR 83.7%. Logistic analysis revealed that high AST (P = 0.041), high CA199 (P = 0.030), low BUN (P = 0.020) could predict less possibility for CR achievement, and portal vein invasion (P = 0.009), higher Child-Pugh stage (P = 0.014) and higher Barcelona BCLC (P = 0.038) were predictors for not achieving ORR. As to survival analysis, high ALP (P = 0.040), low ALB (P = 0.033) and low BUN (P = 0.018), portal vein invasion (P = 0.025), higher ECOG performance status (P = 0.011) and higher Child-Pugh stage (P = 0.001) were predictors for worse OS.

Conclusions: The present study observed that DEB-TACE was effective and well tolerated for liver cancer patients, and high AST, high ALP, low ALB, low BUN, portal vein invasion, higher Child-Pugh stage, higher BCLC stage, higher ECOG performance status were correlated with worse outcomes.

Table 1. Clinical Response of Patients and Nodules Posttreatment

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Patients (n = 99)</th>
<th>Nodules (n = 183)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR (n/%)</td>
<td>16(16.2)</td>
<td>48(25.1)</td>
</tr>
<tr>
<td>PR (n/%)</td>
<td>59(59.6)</td>
<td>90(49.2)</td>
</tr>
<tr>
<td>ORR (n/%)</td>
<td>75(75.8)</td>
<td>136(74.3)</td>
</tr>
<tr>
<td>SD (n/%)</td>
<td>10(10.1)</td>
<td>17(9.3)</td>
</tr>
<tr>
<td>PD (n/%)</td>
<td>14(14.1)</td>
<td>30(16.4)</td>
</tr>
</tbody>
</table>

Abstract No. 509

Same-day discharge after chemoembolization: a predictive model to assist physicians in minimizing overnight admissions
M. AbdelRazek¹, M. Khalaf¹, R. Shah¹, K. Jackson¹, M. Desai², V. Sundaram², N. Kothary¹; ¹Stanford University School of Medicine, Stanford, CA; ²Quantitative Sciences Unit, Department of Medicine, Stanford University, Stanford, CA

Purpose: To develop a predictive model in patients undergoing transcatheter chemoembolization (TACE) for hepatocellular carcinoma (HCC) to identify those at risk for protracted recovery necessitating overnight hospitalization.

Materials: Three-hundred and sixteen patients underwent 438 TACE procedures over a two-year period (2014-16). Procedures were divided into training (193 patients/283 TACEs) and testing (123 patients/155 TACEs) datasets. Independent variables included demographics, laboratory values, tumor characteristics and procedural details. Protracted recovery was defined by the presence of severe pain or nausea requiring intravenous medication beyond the peri-procedural period of 6 hours, increased length of stay and/or a return to the emergency room. The predictive model was developed using conditional inference trees and Lasso regression.

Results: One hundred and forty-eight patients (77%) in the training dataset and 99 patients (80%) in the testing dataset did not require intravenous medications beyond the peri-procedural period of 6 hours, increased length of stay and/or a return to the emergency room. The predictive model was developed using conditional inference trees and Lasso regression.

Abstract No. 509

Same-day discharge after chemoembolization: a predictive model to assist physicians in minimizing overnight admissions
M. AbdelRazek¹, M. Khalaf¹, R. Shah¹, K. Jackson¹, M. Desai², V. Sundaram², N. Kothary¹; ¹Stanford University School of Medicine, Stanford, CA; ²Quantitative Sciences Unit, Department of Medicine, Stanford University, Stanford, CA

Purpose: To develop a predictive model in patients undergoing transcatheter chemoembolization (TACE) for hepatocellular carcinoma (HCC) to identify those at risk for protracted recovery necessitating overnight hospitalization.

Materials: Three-hundred and sixteen patients underwent 438 TACE procedures over a two-year period (2014-16). Procedures were divided into training (193 patients/283 TACEs) and testing (123 patients/155 TACEs) datasets. Independent variables included demographics, laboratory values, tumor characteristics and procedural details. Protracted recovery was defined by the presence of severe pain or nausea requiring intravenous medication beyond the peri-procedural period of 6 hours, increased length of stay and/or a return to the emergency room. The predictive model was developed using conditional inference trees and Lasso regression.

Results: One hundred and forty-eight patients (77%) in the training dataset and 99 patients (80%) in the testing dataset did not require intravenous medications beyond the peri-procedural period (after 77% and 85% TACEs respectively). Overall, grade 3-5 complications occurred after 4.7% TACEs. While age, ethnicity, multifocality and doxorubicin dose reached statistical significance in the training dataset, they were not validated in the testing dataset. Chronic pain and prior protracted recovery (p < 0.0001, both) were the only factors that predicted protracted recovery (AUC of 0.65).
Conclusions: This model demonstrates that most patients with HCC should be considered for same-day discharge after a TACE, irrespective of liver function, tumor burden or patient characteristics. However, chronic pain and past history of protracted pain are reliable predictors of recovery and should be taken into discharge planning.

Abstract No. 510
Extrahepatic collateral supply of hepatocellular carcinoma by the omental arterial: detection with automatic software
M. Mohammed, H. Minami, M. Khalaf, Y. Xia, N. Kothary; Stanford University Hospital, Mountain view, CA; Stanford University, Stanford, CA; Stanford University School of Medicine, Stanford, CA; Stanford University Medical Center, Stanford, CA

Purpose: Extrahepatic collateral (EHC) supply to hepatocellular carcinomas (HCC) by the omental artery can be difficult to detect during transarterial chemoembolization. Herein we evaluate the accuracy of automatic vessel detection software for identifying EHC supply by the omental artery in patients undergoing cone-beam CT (CBCT)-assisted transarterial chemoembolization for HCC.

Materials: Twelve patients with confirmed EHC supply to HCC by the omental artery and 18 patients without EHC supply (n = 33 HCCs) were subject to an automatic vessel detection software. Contrast-enhanced CBCTs and digital subtraction angiograms, acquired from the common hepatic artery, were available for all patients. Confusion matrices of true positives, true negatives, false positives, and false negatives were constructed to assess software detection of EHC arteries.

Results: Mean HCC diameter was 4.1 cm (5.1 cm EHC, 3.4 cm non-EHC HCCs). Of the total 62 arteries supplying 34 HCCs (12 omental, 50 intrahepatic arteries), 59 were detected by the software (10 omental, 49 intrahepatic arteries). While the overall sensitivity of detecting EHC arteries was slightly lower at 83.3%, but with a 100% specificity (95% CI: 55.2% – 95.2% and 84.5% – 100%, respectively).

Conclusions: Previously treated or large HCCs [1] can have EHC supply by the omental arteries, but are often difficult to detect on digital subtraction angiograms. Automatic vessel detection software applied to contrast-enhanced CBCT is an accurate and important tool to help detect EHCs specifically from the omental artery in HCCs during transarterial chemoembolization.

Table 1. Clinical Response of Patients and Nodules

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Patients</th>
<th>Nodules</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR (n/%)</td>
<td>73(19.9)</td>
<td>191(28.6)</td>
</tr>
<tr>
<td>PR (n/%)</td>
<td>219(59.7)</td>
<td>330(49.5)</td>
</tr>
<tr>
<td>ORR (n/%)</td>
<td>292(79.6)</td>
<td>521(78.1)</td>
</tr>
<tr>
<td>SD (n/%)</td>
<td>53(14.4)</td>
<td>103(15.4)</td>
</tr>
<tr>
<td>PD (n/%)</td>
<td>22(6.0)</td>
<td>43(6.4)</td>
</tr>
</tbody>
</table>

Abstract No. 511
The comprehensive analysis of efficacy and safety of CalliSpheres® drug-eluting beads transarterial chemoembolization in 367 patients with liver cancer: a multiple-center, prospective cohort study (CTILC study)
Z. Peng, G. Zhou, W. Yu, G. Shao; The First Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang Province; Zhejiang Provincial People’s Hospital, Hangzhou, Zhejiang Province; Zhejiang Cancer Hospital, Hangzhou, Zhejiang Province

Purpose: To investigate the efficacy, safety and prognostic factors of drug-eluting beads transarterial chemoembolization (DEB-TACE) treatment in Chinese patients with liver cancer.

Materials: 367 liver cancer patients from 24 medical centers were consecutively enrolled in this multiple-center, prospective cohort study including 275 hepatocellular carcinoma (HCC) cases, 37 intrahepatic cholangiocarcinoma (ICC) cases and 55 secondary liver cancer cases. All the patients received CalliSpheres® DEB-TACE treatment on demand. Treatment response, overall survival (OS), change of liver function and adverse events (AEs) were assessed.

Results: DEB-TACE treatment achieved 19.9% complete response (CR) and 79.6% objective response rate (ORR), with mean OS 384 days (95% CI: 375–393 days) totally. CR and ORR were both higher in HCC patients (22.9% and 83.6%) compared with primary ICC patients (8.1% and 67.6%) and secondary liver cancer patients (12.7% and 67.3%), while no difference was discovered in OS. Portal vein invasion was independent risk factor for CR, while portal vein invasion, previous conventional TACE (cTACE) treatment and blood creatinine (BCr) abnormal were independent risk factors for ORR. In addition, largest nodule size ≥5.0 cm, albumin (ALB) abnormal and total bilirubin (TBIL) abnormal independently correlated with unfavorable OS. Most liver function indexes were recovered to baseline levels at 1-3 months after DEB-TACE. Common AEs were pain, fever, vomiting and nausea, most of which were in wild grade.

Conclusions: CalliSpheres® DEB-TACE was efficient and well tolerated in Chinese liver cancer patients, and portal vein invasion, previous cTACE treatment, largest nodule size, abnormal BCr, ALB and TBIL were correlated with worse prognosis independently.

Abstract No. 512
Intraarterial computed tomography–enhancement mapping for response assessment of hepatocellular carcinoma to transarterial chemoembolization: a preliminary analysis
B. Odisio, E. Lin, G. Chintalapani, A. Mahvash, E. Klotz; MD Anderson Cancer Center, Houston, TX; University of Texas MD Anderson Cancer Center, Sugar Land, TX; Siemens healthineers, Houston, TX; Siemens healthineers, Forchheim, TX

Purpose: To evaluate the feasibility and accuracy of utilizing intra-arterial computed tomography (IACT)–based enhancement
mapping (EM) in predicting response of hepatocellular carcinoma (HCC) to transarterial chemoembolization (TACE).

Materials: This single-institution retrospective study included 16 patients (mean age, 66 years, range, 50-77). IACT protocol consisted of two sets of CT scans (non-contrast and intra-arterial contrast-enhanced acquisitions) performed before and after chemoembolic delivery on a hybrid Angio-CT System. After procedure completion, IACT data were processed offline with dedicated EM software (Hepacare, Siemens Healthineers, Germany) which utilizes high-resolution deformable registration and subtraction for residual arterial tumor enhancement assessment. Analysis was done on the full resolution data with an isotropic voxel size of 0.6 mm³. Areas of residual enhancement above the post-chemoembolization background noise level were considered as residual disease. Quantification of these areas within the treated HCC was used to assess individual tumor response according to mRECIST. Study objectives were technical feasibility and accuracy of EM in predicting HCC response by mRECIST on the first routine cross-sectional contrast-enhanced CT or MR imaging (FUI-1) after TACE.

Results: EM was successfully performed in 14 (87.5%) patients (2 patients: suboptimal contrast-enhanced IACT due to catheter dislodgement). Mean time from TACE to FUI-1 was 9.5 weeks. Among the 14 patients successfully analyzed with EM, 21 HCCs were treated with TACE (mean diameter, 2.5 cm [range 1-6.3]; mean number of HCCs per patient, 1.5 [range 1-3]). Tumor response prediction based on EM showed complete response in 19 (86%) and partial response in 3 (14%) of HCCs, respectively. Response assessment by FUI-1 fully agreed with EM response assessment for all 21 HCCs treated with TACE.

Conclusions: Dedicated EM using the proposed IACT imaging protocol was feasible and highly accurate in predicting response after TACE. Further studies are warranted to validate and investigate the role of this method for intraprocedural immediate response assessment and subsequent decision making.

Abstract No. 513

Hepatocellular carcinoma treated with conventional versus drug-eluting bead transarterial chemoembolization: clinical and pathologic outcomes following bridge to transplant

A. Moreland1, C. Georgiades1, R. Liddell1, K. Hong1; 1Johns Hopkins Hospital, Baltimore, MD

Purpose: Locoregional therapy serves an important role in bridging to liver transplantation for patients with unresectable HCC. However, there is limited literature on comparative efficacy of locoregional treatment options in the post-transplant period. The present study examines our institutional experience with cTACE versus DEB-TACE in patients bridged to transplant, with explant gross and microscopic pathologic correlation.

Materials: An IRB-exempt, retrospective review of an institutional database was conducted for all patients with HCC treated with cTACE or DEB-TACE alone from December 2010 through January 2016 who were successfully bridged to liver transplant. Patient demographics, tumor characteristics, MELD scores, explant pathology, and post-transplant clinical course were recorded.

Results: 92 total patients were treated during the study period (n = 52 with cTACE, n = 40 with DEB-TACE). Median MELD score at the time of first procedure was 10 vs 9, respectively (p = 0.13). Median number of tumors per patient at time of first procedure was n = 1 in each group (p = 0.96), while median maximum pretreatment tumor diameter was 2.4 cm among cTACE and 2.6 cm among DEB-TACE patients (p = 0.14). Median duration of follow-up was 24 versus 46 months from the first procedure, and 16 versus 38 months from transplant (cTACE vs DEB-TACE groups, respectively). Median number of residual/recurrent tumors at time of explant was n = 1 in both groups (p = 0.39), while median maximum percent tumor necrosis on explant histology was 90% in both groups (p = 0.79). Post transplant recurrent disease was detected on follow-up imaging in 6% (n = 3) of cTACE patients and 10% (n = 4) of DEB-TACE patients (RR = 0.58; p = 0.44). HCC-specific and overall survival from time of first procedure were not significantly different between groups (DSS: HR 0.19, p = 0.13; OS: HR 1.2, p = 0.77).

Conclusions: Evaluation of post-transplant outcomes among patients with HCC treated with stand-alone cTACE versus DEB-TACE revealed no difference in post-transplant explant pathologic or clinical primary outcomes between groups. Therefore, peri-procedural factors appear to be more important than long-term post-transplant outcomes in choice of treatment modality.

Abstract No. 514

Injectable thermo-sensitive hydrogels as chemoembolic drug delivery agents for interventional applications

S. McLaughlin1, S. Hunt2, G. Nadolski1, T. Gade3; 1University of Pennsylvania, Philadelphia, PA; 2Hospital of the University of Pennsylvania, PHILADELPHIA, PA; 3Hospital of the University of Pennsylvania, Philadelphia, PA

Purpose: Controversy exist when discussing disease control of hepatocellular carcinoma in regards to bland embolization verses drug loaded microspheres. While the reasons for the absence of convincing data supporting the use of embolic microspheres in combination with chemotherapy are multiple, the importance of achieving complete vascular occlusion and sustained drug release are clear. Therefore, the development of biodegradable injectable drug loaded materials that can “cast” the tumor capillary bed would be advantageous. Chitosan is an FDA approved biocompatible and biodegradable polysaccharide derived from the crustacean exoskeleton. It can be used as a delivery vehicle for small molecules.

Materials: Chitosan was dissolved in 0.25% acetic acid solution (1.44% w/v) under magnetic stirring for approximately 12 hours at room temperature. The solution was sterilized by autoclaving at 121°C for 30 min. Chitosan (5 mL) was mixed with 200µL of ammonium hydrogen phosphate (AHP) solution (60% aqueous solution) via two syringe vigorous mixing method. The pH of the mixture was in the range of 7-7.2. Doxorubicin (5 mg/mL) was loaded into chitosan solution during magnetic stirring for release studies. The drug released from the hydrogel was determined by measuring the concentrations of the doxorubicin after set time
points with a UV-vis spectrophotometer at 483 nm with a standard curve constructed with known concentrations of doxorubicin.

Results: The resulting solution can be injected through a microcatheter with gelation times range from 1-3 minutes at 37 degrees. In vitro degradation and release studies were performed with doxorubicin from the hydrogel. It was determined that the hydrogels are stable in an aqueous environment for up to 90 days. Additionally, when loaded with 5 mg/ml doxorubicin, drug release profiles demonstrated up to 70% delivery of the drug at 28 days.

Conclusions: We hypothesized that the development of a chitosan hydrogel to enable casting and drug release can be used as an intravascular chemoembolic agent. These gels demonstrate controlled, sustained release of doxorubicin and can be injected through a microcatheter in preparation for in-vivo trials.

### Abstract No. 515

**RAPID TACE: radial access provides improved discharge times in transarterial chemoembolization**

J. Titano1, J. Di Capua1, C. Welch1, D. Biederman2, R. Patel3, M. Ranade4, V. Bishay5, E. Kim6, F. Nowakowski7, R. Lookstein8, A. Fischman1; 1Icahn School of Medicine at Mount Sinai, New York, NY; 2Yale School of Medicine, New Haven, CT; 3Mount Sinai Medical Center, New York, NY; 4Mount Sinai Hospital, New York, NY; 5Icahn School of Medicine at Mount Sinai Hospital, New York, NY

**Purpose:** To compare length of stay (LOS) for transradial access (TRA) and transfemoral access (TFA) during transarterial chemoembolization (TACE). Current data comparing TRA with TFA with respect to LOS has been mixed with several studies demonstrating shorter length of stay in TRA cases compared to TFA cases in percutaneous coronary and splenic interventions.

**Materials:** Retrospective review of TACE procedures performed between 11/2016 and 9/2017 yielded a total of 167 cases (TRA-TACE (n = 124), TFA-TACE (n = 43)) performed on 133 patients. Six patients underwent both TRA- and TFA-TACE within the study period. Patient demographics, procedure characteristics, fluoroscopy time (FT), and discharge time (DT) were recorded. Outcome variables included technical success (TS), adverse events (AEs), and LOS.

**Results:** Patient and procedural data is presented in Table 1. Overall TS was achieved in 98.1% of cases with 1 radial-to-femoral crossover (0.8%). Ten patients (6%) were admitted overnight with no significant difference in admission rates between TRA and TFA (p = 0.070). Minor access site hematoma developed in 1 (0.8%) TRA case. There was no significant difference in FT (TRA 21.5 ± 11.0 min vs. TFA 24.5 ± 16.0 min, p = 0.278) or overnight admissions (p = 0.553); however, there was a significant reduction in time from procedure completion to transfer (TRA 127.8 ± 32.3 min vs. TFA 224.3 ± 84.3 min, p = 0.049) for admitted patients. For same-day procedures, there was a significant reduction in TRA-LOS (120.0 ± 45.5 min) compared with TFA-LOS (196.2 ± 63.7 min) (p<0.001).

**Conclusions:** TRA-TACE reduces LOS compared to TFA-TACE with similar rates of TS and FT.

### Table 1. Baseline Patient and Procedure Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Femoral</th>
<th>Radial</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>66.4 ± 9.4</td>
<td>65.5 ± 8.8</td>
<td>0.589</td>
</tr>
<tr>
<td>Male Sex</td>
<td>81.1%</td>
<td>68.6%</td>
<td>0.149</td>
</tr>
<tr>
<td>Caucasian Ethnicity</td>
<td>18.9%</td>
<td>34.3%</td>
<td>0.125</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.5 ± 7.7</td>
<td>27.8 ± 5.7</td>
<td>0.848</td>
</tr>
<tr>
<td>HCC Tumor</td>
<td>100%</td>
<td>96.1%</td>
<td>0.684</td>
</tr>
<tr>
<td>5Fr Sheath</td>
<td>97.7%</td>
<td>100%</td>
<td>0.578</td>
</tr>
<tr>
<td>Barbeau B waveform</td>
<td>-</td>
<td>73.4%</td>
<td>-</td>
</tr>
<tr>
<td>5Fr Sarah radial</td>
<td>-</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>5Fr Contra 2</td>
<td>53.5%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TR band closure</td>
<td>-</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>Anglo-Seal closure</td>
<td>62.8%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Abstract No. 516

**Treatment of parasitized gastric arteries supplying hepatic tumors**

W. Fletcher1, J. Louie2, N. Kothary1, D. Wang3, D. Sze4; 1Stanford University, Stanford, CA

**Purpose:** Parasitized extrahepatic arteries that supply hepatic tumors are typically amenable to direct embolotherapy or to redistribution of flow. Parasitized gastric arteries, however, present severe risks for nontarget chemo or radioembolization since this can result in life-threatening ulcers. This retrospective study reviewed techniques and outcomes for patients with parasitized gastric arteries undergoing embolotherapy.

**Materials:** 3670 transarterial chemoembolization (TACE) procedures on 1711 patients and 721 90Y radioembolization (RE) procedures on 614 patients from 2003-2017 were retrospectively reviewed. 616 procedures (14.0%) required treatment of parasitized extrahepatic arteries; only 14 patients (0.6%) with 17 parasitized gastric arteries were identified: 7 left gastric, 5 right gastric, and 5 right gastroepiploic arteries. Treatment consisted of superselective TACE via parasitized arteries, or bland embolization using coils, glue, or large particles for flow redistribution followed by hepatic TACE or RE. Radiographic response was evaluated by mRECIST, and toxicity graded by CTCAE v4.03.

**Results:** 12 patients underwent 15 treatments, while 2 patients were not treated due to failure to select the parasitized gastric arteries. All tumors with parasitized gastric artery supply were in the left lobe, and 11 of 14 patients also had non-gastric parasitized arteries. 10 of 14 patients had prior surgery or embolotherapy. 11 had hepatocellular carcinoma and 3 had metastases (pancreatic neuroendocrine, gastrointestinal stromal tumor, leiomyosarcoma). Of the 15 treatments, 6 were superselective TACE, 7 were redistributions, and 2 were both. After redistribution, 2 underwent TACE, 6 underwent RE, and 1 underwent percutaneous ethanol injection. Available radiographic assessment after 12 interventions showed 1 progressive disease, 6 stable disease, 4 partial response, and 1 complete response. No ulcers were documented, and only transient grade 1-2 abdominal pain occurred in 7 patients.

**Conclusions:** Parasitization of gastric arteries is rare but poses special challenges to embolotherapy. Most can be treated safely and effectively by superselective TACE or hepatic embolotherapy after redistribution.
Abstract No. 517

Conventional vs. drug-eluting beads TACE for hepatocellular carcinoma: a propensity score-weighted comparison

E. Chen1, N. Nezami1, L. Savic1, F. Laage-Gaupp1, N. Murail1, A. Windham-Herman1, C. Hamm1, C. Wang1, M. Lin1, T. Schlachter1, J. Chapiro1, J. Geschwind1; 1Yale University School of Medicine, New Haven, CT

Purpose: The purpose of this study was to compare the efficacy and safety of conventional transarterial chemoembolization (cTACE) with drug-eluting beads (DEB)-TACE in patients with hepatocellular carcinoma (HCC) without portal venous thrombosis (PVT).

Materials: This retrospective analysis included a total of 370 patients with HCC, who were treated with either cTACE (N = 248) or DEB-TACE (N = 122) between 2000 and 2014. Clinical and biochemical toxicities of Grade ≥3 (CTAEv4) were recorded for all patients. Survival analysis was conducted using univariable and multivariate Cox proportional hazards models and Kaplan-Meier analysis using log-rank test and propensity score weighting via a generalized boosted model. In addition, subgroup analysis was performed to compare survival after cTACE and DEB-TACE stratified according to tumor size (>3 cm or >5 cm) and tumor morphology (infiltrative vs. nodular) on baseline imaging.

Results: There was no significant difference in the prevalence of adverse events except for abdominal pain/discomfort which occurred more frequently after DEB-TACE (87.1%) than after cTACE (75.1%; p = .02). The median overall survival (MOS) of the entire cohort was 28.1 mo. There was no significant difference in MOS between cTACE (19.5 mo) and DEB-TACE (22.2 mo) patients after propensity score weighing (p = .405). However, in patients with infiltrative disease, cTACE achieved significantly longer MOS (12.1 mo) compared to DEB-TACE (8.6 mo; p = .033). Conversely, in patients with nodular disease, DEB-TACE patients (25.4 mo) demonstrated significantly greater survival compared to cTACE patients (23.5 mo; p = .023). Stratification according to tumor size did not achieve a significant separation of survival curves.

Conclusions: This study did not demonstrate a significant difference in efficacy and toxicity between cTACE and DEB-TACE for the treatment of HCC without PVT. However, subgroup analysis of the cohort revealed that cTACE showed superior efficacy in patients with infiltrative disease whereas DEB-TACE was more effective in nodular tumors. Thus, tumor morphology and distribution on baseline imaging should be used as a parameter to inform decisions on the selection of embolic materials for TACE.

Abstract No. 519

Does arterial feeder on cross-sectional imaging predict treatment response and survival after TACE for hepatocellular carcinoma? A multilevel analysis

J. Guan1, S. Laroia1, M. Dunlay2, L. Huang3, G. Yang3, H. Victor1, E. Sung1, S. Sun1, S. Wang1, B. O’Shea1, P. Nagpal1; 1University of Iowa Hospitals and Clinics, Iowa City, IA; 2Mayo Clinic College of Medicine and Science, Rochester, MN; 3The Ohio State University College of Medicine, Columbus, OH

Purpose: To identify factors affecting tumor recurrence in patients with unresectable hepatocellular carcinoma (HCC) treated with transarterial chemoembolization (TACE), who present complete imaging response (CIR) postprocedure.

Materials: Retrospective single-center study. Consecutive patients with unresectable HCC, treated with TACE from January 2000 to December 2016, who presented CIR in the first post-procedure imaging control, were included. Patients who received contemporary adjuvant treatment (radiofrequency, microwave or alcoholization) or patients without imaging follow-up were excluded. CIR was defined as absence of contrast-enhancement of the treated lesion in arterial phase. As local recurrence were considered: detection of contrast-enhancement in the treated lesions in arterial phase, washout of the treated lesions in portal-venous phase, or an increase in lesion size after CIR. Age, gender, etiology of chronic liver damage, Child-Pugh classification, MELD-Na score, number, size and location of HCC, and chemoembolization technique were analyzed. Chi-square test was used to compare qualitative variables, and Wilcoxon or t-student test for the quantitative variables. Multiple logistic regression analysis was performed to study factors that modify tumor recurrence. A p-value less than 0.05 was considered statistically significant.

Results: From a total of 206 HCC in 148 patients treated with TACE during the study period, 71 tumors were analyzed after applying the inclusion/exclusion criteria. The mean follow-up was 9.7 months (range, 1-36 months). Tumor recurrence at 6-, 12- and 24-months was 21%, 32% and 42%, respectively. In multivariate analysis, tumor size ≥3 cm was the only factor that demonstrated a significant association with tumor recurrence, with OR 6.41 (95% CI: 1.71-23.97) (p = 0.006).

Conclusions: Recurrence of HCC with complete imaging response after treatment with TACE is common, a result that is consistent with previous reports. Tumor size ≥ 3 cm is significantly associated with an increased risk of tumor recurrence.

Abstract No. 518

Factors associated with recurrence of hepatocellular carcinoma with complete imaging response after treatment with transarterial chemoembolization

E. Bravo1, T. Cermenati1, N. Martinez1, B. Leon1, J. Bravo1, J. De Gracia1, C. Moya1, F. Pizarro1, P. Palavecino1; 1University of Chile, Santiago, Chile

Purpose: To identify factors affecting tumor recurrence in patients with unresectable hepatocellular carcinoma (HCC) treated with transcatheter chemoembolization (TACE) angiogram for hepatocellular cancer (HCC) has been shown to predict tumor necrosis on subsequent pathology. However, whether this finding can translate into a useful clinical predictor for post-chemoembolization response and survival is unknown. This study aimed to determine whether the presence of an arterial feeder vessel on pre-TACE cross-sectional imaging predicts treatment response and survival after TACE for HCC.

Materials: After IRB approval, retrospective med-rec search for all TACE procedures performed for HCC in 2016 yielded 71 patients that underwent 149 TACE sessions spanning 2013 to 2017.
Patients consisted of 56 males (79%), mean age of 62 (r, 37-86), with each patient undergoing 1-5 TACE sessions. Endpoints included target lesion response and overall treatment response, as defined by the mRECIST criteria, as well as patient survival. Pre-procedural liver MRI was reviewed for presence of arterial feeder. Multilevel logistic regressions and Cox regressions were used to assess the effects of arterial feeder presence on treatment response and patient survival, respectively, adjusting for other covariates.

**Results:** Overall treatment response (complete and partial) was seen in 56% of TACE treatments in 69% of patients. Arterial feeder was present on pre-procedural MRI in 36% of TACE sessions. The presence of arterial feeder on pre-TACE MRI led to better target lesion response (OR = 20.43, p = 0.0001) and overall treatment response (OR = 14.91, p<0.0001). Mean survival for all patients was 21.8 months (r, 1.3-54.8). Advanced age (HR = 1.05, p = 0.046) and increased tumor size (HR = 1.15, p = 0.002) were associated with reduced patient survival after TACE. The presence of arterial feeder also trended towards increased survival (HR = 0.41, p = 0.0696), although this relationship did not reach statistical significance.

**Conclusions:** The presence of an arterial feeder on pre-TACE MRI predicts both target lesion response and overall treatment response after TACE. Further research to validate if presence of arterial feeder can be a non-invasive marker of tumor response and improved patient survival is warranted.

---

**Abstract No. 520**

**Survival analysis using albumin-bilirubin grade for patients treated with drug-eluting bead transarterial chemoembolization (DEB-TACE) for hepatocellular carcinoma**

J. Sung, D. Biederman, V. Bishay, M. Ranade, R. Patel, F. Nowakowski, A. Fischman, R. Lookstein, E. Kim; 3Icahn School of Medicine at Mount Sinai, New York, NY; 2Suny Downstate College of Medicine, New Haven, CT; 1SUNY Downstate College of Medicine, Brooklyn, NY; 2Yale School of Medicine, New Haven, CT; 3Icahn School of Medicine at Mount Sinai, New York, NY

**Purpose:** To compare the efficacy of the albumin-bilirubin (ALBI) grade classification system and Child-Pugh (CP) classification system in differentiating survival among patients with hepatocellular carcinoma (HCC) receiving drug-eluting bead transarterial chemoembolization (DEB-TACE).

**Materials:** An IRB-approved, single-center retrospective review (January 2009–September 2016) found 303 patients with HCC who had received DEB-TACE (100-300μm LC Beads with 50 mg doxorubicin, BTG, West Conshohocken, PA) without concomitant locoregional therapy within 30 days. Clinical toxicities were recorded using criteria based on the Common Terminology Criteria for Adverse Events, Version 4.03a. Survival analysis was performed using Kaplan-Meier methods and censored for curative therapy. Survival curves were stratified based on albumin-bilirubin grade, Child-Pugh class, Barcelona Clinic Liver Cancer (BCLC) staging, presence of ascites and Eastern Cooperative Oncology Group (ECOG) performance status. Discriminatory ability of survival curves was calculated by C-index.

**Results:** Kaplan-Meier curves stratified by ALBI grade produced distinct, non-overlapping curves (p < 0.001) that showed greater discriminatory ability compared to CP class (C-index = 0.568, 0.545, respectively). Substratification of CP A by ALBI grade yielded distinct curves (p = 0.023). Analyses of measures of clinical decompensation (presence of ascites, ECOG greater than 0, CP B8 or greater) substratified by ALBI grade yielded distinct curves only for patients without clinical decompensation (p < 0.001, p < 0.001, p = 0.003, respectively). Substratification of BCLC by ALBI grade yielded greater discriminatory ability compared to substratification by CP class (C-index = 0.573, 0.565, respectively). Additionally for BCLC B patients, substratification by ALBI grade yielded distinct curves while CP class did not (p = 0.011, 0.379, respectively).

**Conclusions:** ALBI grade shows improved discriminatory ability versus Child-Pugh class in differentiating overall survival among patients with hepatocellular carcinoma receiving DEB-TACE. Furthermore, ALBI grade was efficacious in substratifying survival among Child-Pugh A and BCLC B patients where CP class was not.

---

**Abstract No. 521**

**A retrospective analysis of combined transarterial chemoembolization and microwave ablation therapy versus microwave ablation alone on ablation volumes, clinical response, and outcomes in patients with hepatocellular carcinoma**

E. Pang, J. Guynan, R. Bant, J. Kao, L. Morel-Ovalle, K. Pereira, S. Gadani, K. Vaheesian, A. Fang; 1Saint Louis University, St. Louis, MO

**Purpose:** To compare the ablation volumes, clinical response, and outcomes after microwave ablation (MVA) with and without transarterial chemoembolization (TACE) in patients with hepatocellular carcinoma (HCC).

**Materials:** This retrospective study included 82 patients with 92 HCC who underwent MVA between 2013 and 2017. TACE was performed before MVA in 34 patients (26 M, 8 F; mean age: 62.9 y ± 7.7) while 48 patients underwent MVA only (34 M, 14 F; mean age: 63.6 y ± 8.8). Patients were followed with CT or MR imaging for at least a year to identify tumor progression. Clinical and technical factors were reviewed. Ablation length, diameter, and volumes on first follow-up cross-sectional imaging were calculated. Complete response (CR), partial response (PR), stable disease (SD), and progressive disease (PD) were evaluated according to mRECIST. Time to progression (TTP), progression-free survival (PFS), and overall survival (OS) were compared between groups.

**Results:** There were no significant differences between groups in terms of tumor etiology, ablation time, wattage, ECOG, Child-Pugh, and BCLC scores. Mean MELD scores were higher in the MVA-only group compared to the TACE group (11.7 ± 4.5 vs. 9.3 ± 2.3, p = 0.0185). Mean tumor size was larger in the TACE group compared to the MVA-only group (3 cm ± 1.2 vs. 2.4 cm ± 1.1, p = 0.0142). Mean ablation volumes were larger in the TACE group compared to the MVA-only group (49.4 cm³ ± 38.3 vs. 28.4 cm³ ± 20.8, p = 0.0036). There were no significant differences between the TACE and MVA-only groups in terms of CR, PR, SD, or PD on follow-up imaging, as well as clinical outcomes, including TTP (median: 4 vs. 5 mo), PFS (median: 9.5 vs. 12.5 mo), or OS (median: 20 vs 18 mo). Overall survival was similar between groups at 12 mo (93.9% vs. 89.6%) and 18 mo (85.2% vs. 68.6%).

**Conclusions:** Combined TACE and MVA therapy leads to larger ablation volumes and effectively treats larger HCC but does not
Outcomes of TACE for hepatocellular carcinoma in patients with HIV infection
E. Phillips1, R. Kohlbrenner2, A. True-Yasaki3, N. Fidelman2, A. Taylor2, E. Lehman2, M. Kohi2, K. Koli2, R. Kerlan2, N. Mehta2, 1California Northstate University, Elk Grove, CA; 2University of California San Francisco, San Francisco, CA

Purpose: To investigate the safety and effectiveness of trans-arterial chemoembolization (TACE) in hepatocellular carcinoma (HCC) patients with HIV infection. Materials: Ninety TACE procedures (60 conventional TACE, 30 drug-eluting bead TACE) in 31 HIV-positive patients (all men; mean age 57 years; mean CD4 340, 100% on antiretroviral therapy) performed between September 2006 and August 2017 were examined as a part of retrospective study. Risk factors for HCC included chronic hepatitis C (61%), chronic hepatitis B (26%), and multifactorial (13%). Median baseline total bilirubin was 1.1 mg/dL (range, 0.3-3.7). Mean MELD and Child-Pugh scores prior to TACE were 12 (range, 6-28) and 7 (range, 5-9), respectively. Baseline alpha fetoprotein (AFP) prior to any TACE procedure was less than 10 μg/L in 22% of patients, between 10 and 100 μg/L in 43%, and greater than 100 μg/L in 35%. For 18 patients (58%) TACE was performed for HCC within Milan Criteria as a "bridge" to liver transplant; 5 patients (16%) underwent TACE in an attempt to downstage into Milan Criteria, while 8 patients (26%) underwent TACE for palliative purposes. For each procedure, laboratory and clinical adverse events and response rates were assessed. Overall survival (OS) and transplant rates were also determined. Results: Symptoms of post-embolization syndrome were reported after 46% of TACE procedures. New or worsening hyperbilirubinemia was the most common postprocedure laboratory abnormality (58%). One infectious complication (urinary tract infection) occurred within 1 month of TACE. Complete response and partial response on follow-up cross sectional imaging was noted after 34% and 52% of TACE procedures, respectively. Of 21 eligible transplant candidates, 14 received transplants and 3 remain listed. Of transplant recipients, mean survival or follow-up was 55 months (range, 8-134, 3 transplant recipients deceased). Mean OS for patients not on the transplant list was 16 months from initial treatment, with a mean 3.4 treatment sessions (range, 1-7) per patient. Conclusions: TACE is a safe and effective treatment for HCC in patients with HIV infection.

Locoregional therapy for liver metastases in uveal melanoma: improvements in progression-free survival and predictors of response
A. Beardsley1, R. Sheth2, L. Haydu2, J. Gardner2, J. Kuban2, A. Tam2, S. Patel2, 1Baylor College of Medicine, Houston, TX; 2MD Anderson Cancer Center, Houston, TX; 3UT/MD Anderson, Houston, TX

Purpose: Liver is the most common metastatic site in uveal melanoma, and as such, locoregional therapies play an important role in the management of these patients. The purpose of this study was to determine the relative effectiveness of different locoregional therapies for uveal melanoma liver metastases and to determine predictors of response.

Materials: A single-institution, IRB-approved retrospective review of patients with uveal melanoma who underwent hepatic arterial infusion (HAI) therapy, chemoembolization, bland embolization, radioembolization, or percutaneous thermal ablation was performed. Progression-free and overall survival analysis was performed, and predictors for treatment response were determined by Cox proportional hazards.

Results: There was a significant inverse correlation between tumor volume and FLR hypertrophy after PVE. There was no significant difference in survival between all three treatment groups. Though there was a trend towards improved survival with cisplatin versus doxorubicin chemoembolization and bland embolization. Pre-procedural LDH (P = 0.04) and neutrophil-to-lymphocyte ratio (NLR) (P = 0.02) were significant predictors of progression-free survival for patients undergoing TTT (P < 0.05), while tumor volume, tumor focality, prior chemotherapy, and time interval from primary tumor presentation to development of metastasis were not.

Conclusions: TTT improves progression-free survival relative to HAI in patients with uveal melanoma liver metastases. Additionally, preprocedure NLR is a significant predictor of treatment response to TTT, and LDH may be an early indicator of tumor recurrence in patients who undergo TTT.

Future liver remnant hypertrophy after portal vein embolization is inversely correlated to intrahepatic tumor burden
E. Takahashi1, C. Fleming1, J. Andrews1; 1Mayo Clinic, Rochester, MN

Purpose: To determine if there is an association between intrahepatic tumor volume and future liver remnant (FLR) hypertrophy after portal vein embolization (PVE).

Materials: Forty-four consecutive patients with hepatocellular carcinoma or metastatic colorectal cancer who underwent PVE from 2009-2017 and who had complete imaging follow-up were retrospectively reviewed. Eleven patients were excluded for >5 intrahepatic tumors to maximize accurate tumor volume measurements. Volumetric analyses of the patient livers before and after PVE as well as pre-embolization intrahepatic tumor burden were performed.

Results: There was a significant inverse correlation between tumor volume and FLR hypertrophy after PVE (Spearman r = -0.53, P = 0.002). Initial FLR volume was also inversely correlated with
A rabbit model of gastric cancer established by injecting VX2 tumor pieces through left gastric artery catheterization

H. Yu1, G. Feng1, J. Feng2, B. Zhou1, W. Xi1, F. Yan1, B. Wu1, G. Ying1, J. Zhang1, H. Chen1, J. Chen1; 1Jiangsu Cancer Hospital, Jiangsu Institute of Cancer Research, NMU Affiliated Affiliated Cancer Hospital, Nanjing City, Jiangsu Province; 2Jiyuan Hospital of Traditional Chinese Medicine, Jiyuan, Henan

Purpose: To establish gastric cancer in rabbits by injecting VX2 tumor pieces into the left gastric artery under the guidance of the digital subtraction angiography (DSA) in 12 New Zealand rabbits. One week after the implantation, DSA and air barium double contrast radiography were performed to evaluate the growth of the tumors. Three rabbits were then sacrificed for histopathological analysis of the tumors immediately and survival time was observed in the other nine rabbits.

Results: The left gastric artery catheterization was successfully achieved in all rabbits. All animals survived one week after the implantation. Gastric tumors were demonstrated with DSA and the air barium double contrast radiography. The masses, ulcers and mucous membrane edema could be found in the stomachs of the three rabbits, one week after the implantation of VX2 tumor pieces. Gastric tumors with remarkable perforations were confirmed in the other nine animals. The median survival time of the VX2 gastric cancer rabbits was 12 days in the current study.

Conclusions: The implantation of VX2 tumor pieces into the left gastric artery is feasible to establish gastric cancer in rabbits, a promising animal model for the researchers on interventional oncology, radiology, and surgery.

Abstract No. 527

Factors influencing retinoblastoma (Rb) response to treatment in children undergoing selective ophthalmic artery infusion chemotherapy (SOAIC)

K. Abraham1, K. Karani2, Z. Correa3, T. Abruzzo4; 1University of California, San Francisco, San Francisco, CA

Purpose: To identify factors that correlate with treatment response in Rb patients treated with SOAIC.

Materials: All patients undergoing SOAIC for Rb at a single tertiary care Children’s Hospital between December 2008 and July 2017. Retrospective chart review was used to document patient and tumor characteristics including age, sex, International Classification of Intra-ocular Rb grade, laterality, multiplicity, and prior treatment history for all patients. Analysis of factors influencing treatment response was restricted to the first cycle of SOAIC since repeat treatment cycles would be affected by previous treatment cycles in an unpredictable manner that could not be modeled. Tumor response to SOAIC was evaluated on a binary scale [1] visible regression, vs 2) no response.] by an ophthalmologic exam under anesthesia (EUA) by an experienced ocular oncologic surgeon. We examined correlation of treatment response with different factors including chemotherapy agent, chemotherapy time, adjunctive intra-arterial (IA) verapamil, adjunctive intra-nasal Afrin, and balloon occlusion of external carotid artery (ECA). Previous exposure to systemic chemotherapy and chemo-refractory disease was controlled for.

Results: 39 eyes were successfully treated in 34 patients by superelective microcatheter infusion of chemotherapy directly into the ophthalmic artery. There were no technical failures or alternative methods of chemotherapy. 56% of treated eyes were chemotherapy naïve at the time of first SOAIC cycle. 91% of chemo-naïve eyes showed visible tumor regression vs 71% of pretreated eyes. Factors independently and significantly correlated with a positive response to SOAIC included adjunctive IA verapamil [p = 0.037], and IA melphalan (vs topotecan) [p = <0.001].

Conclusions: In the treatment of Rb with SOAIC, IA melphalan is superior to IA topotecan, and adjunctive IA verapamil is positively correlated with a positive treatment effect.
Abstract No. 528

Antivascular ultrasound (AVUS) demonstrates vascular disruption in a dose-dependent manner in a DEN rat model of hepatocellular carcinoma


Purpose: Previous studies have shown low-intensity ultrasound used with intravascular microbubbles (uB) disrupts tumor neovascularure. This study aims to evaluate changes in vascular perfusion following antivascular ultrasound (AVUS) therapy in a translational rat model of hepatocellular carcinoma (HCC).

Materials: HCC was induced in 6 Wistar rats via diethylnitrosamine (DEN) ingested in drinking water for 12 weeks. Rats received AVUS therapy at low and high doses. The low dose group (n = 3) was treated at 1 W/cm² for 1 min with 0.2 mL perfutren lipid microspheres (microbubbles, uB) injected IV. The high dose group (n = 3) was treated at 2 W/cm² for 2 min with 0.7 mL IV uB. Perfusion was assessed by nonlinear contrast (NLC) and power Doppler (PD) ultrasound imaging before and after therapy. From each imaging mode, peak enhancement (PE) and perfusion index (PI) were measured. Histologic analysis of H&E and trichrome sections was performed after natural death or euthanasia.

Results: In the high-dose group, perfusional measures of PE (PD) decreased by 32.1% on average, and PI decreased 29.3% following AVUS therapy. NLC similarly showed average decreases: reduction in PE by 42.9% and PI by 44.8%. Histopathologic correlation showed increased hemorrhagic necrosis covering 61.5% of tumors' cross-sectional area. In contrast, the low-dose group showed only modest changes in perfusion, and on average showed slight increases in perfusional measures (PE and PI). PD showed an average increase of 4.5% and 6.9% in PE and PI, respectively. NLC similarly showed average increases of 1.3% and 54.9% in PE and PI, respectively. Histologically, the low dose group showed less severe hemorrhagic necrosis in only 19.5% tumor cross sectional area.

Conclusions: High-dose AVUS showed decreased perfusion and increased hemorrhagic necrosis on US and histology, while changes were less severe with low-dose AVUS. These dose-dependent effects are now being investigated in our translational model of HCC to further refine this novel, image-guided interventional therapy.

Abstract No. 530

Association of radiological complete response following locoregional therapy prior to liver transplantation with long-term outcomes of hepatocellular carcinoma patients

<table>
<thead>
<tr>
<th>Max Dose uB</th>
<th>%Hemorrhage on Tumor Cross-Sections (SEM)</th>
<th>PE (PD) Decrease Avg (%) (SEM)</th>
<th>PI (PD) Decrease Avg (%) (SEM)</th>
<th>PE (NLC) Decrease Avg (%) (SEM)</th>
<th>PI (NLC) Decrease Avg (%) (SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-dose group</td>
<td>0.7mL</td>
<td>61.5 (10.6)</td>
<td>32.1 (15.2)</td>
<td>29.3 (17.0)</td>
<td>42.9 (18.2)</td>
</tr>
<tr>
<td>Low-dose group</td>
<td>0.3mL</td>
<td>19.5 (9.6)</td>
<td>-4.5 (6.7)</td>
<td>-6.9 (13.7)</td>
<td>-1.3 (13.0)</td>
</tr>
</tbody>
</table>

Abstract No. 529

Celiac and/or splanchnic nerve block/neurolysis: comparison of techniques, efficacy, and complications

C. Chao1, B. Tolaymat2, G. Li3; 1University of Maryland, Baltimore, MD; 2University of Maryland School of Medicine, Baltimore, MD; 3University of Maryland, Baltimore, MD

Purpose: To evaluate the long-term outcomes of patients with hepatocellular carcinoma (HCC) who achieve complete vs. incomplete imaging response on pretransplant imaging studies following locoregional therapy (LRT) prior to orthotopic liver transplantation (OLT).
Materials: Institutional database was reviewed to identify the patients listed for OLT with HCC (Mar 1998-Dec 2010). Patient and baseline tumor characteristics as well as type of LRT and post-transplant outcomes were recorded. Imaging response to LRT was evaluated on pretreatment contrast-enhanced CT or MRI based on mRECIST criteria. Survival analysis was performed using Kaplan-Meier estimation and log-rank test.

Results: 155 HCC patients were identified who received OLT following LRT for HCC. Posttreatment imaging was available in 109 (70%) patients while 46 patients (30%) were transplanted after LRT. The table lists the baseline demographic, clinical and tumor characteristics of the study population at the time of diagnosis. Type of LRT was TACE in 55, RFA in 9, and sequential TACE and RFA in 1 patient for the complete response group compared to TACE in 34, RFA in 4, sequential TACE and RFA in 5 and radioembolization in 1 for the incomplete response group (p-value = 0.1). Mean progression-free survival from the time of listing was significantly better for HCC patients who achieved complete response after LRT (mean survival of 144 ± 8.4 vs. 131 ± 13.9 months, p-value = 0.04). 3, 5 and 7-year recurrence free survival after OLT was 81%, 74% and 65% for patients in the complete response group compared to 68%, 59% and 47% for patients with incomplete response (p value = 0.04).

Conclusions: Achieving an imaging complete response following LRT prior to OLT for HCC is associated with better progression-free survival after being listed and improved recurrence free survival after liver transplant.

<table>
<thead>
<tr>
<th>Age at Diagnosis (Female)</th>
<th>Gender</th>
<th>MELD Score</th>
<th>Days on Waitlist</th>
<th>Mean Longest Diameter of Largest HCC at Diagnosis (mm)</th>
<th>Mean Number of Tumors</th>
<th>BCLC 0</th>
<th>BCLC A</th>
<th>BCLC B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete response (n = 65)</td>
<td>55.5 ± 1.1</td>
<td>10 (15%)</td>
<td>10.3 ± 0.5</td>
<td>242.4 ± 39.9</td>
<td>28.5 ± 1.3</td>
<td>1.5 ± 0.1</td>
<td>5 (8%)</td>
<td>39 (60%)</td>
</tr>
<tr>
<td>Incomplete response (n = 44)</td>
<td>57.5 ± 1.1</td>
<td>8 (18%)</td>
<td>10.1 ± 0.4</td>
<td>227.2 ± 40.0</td>
<td>30.1 ± 1.7</td>
<td>1.7 ± 0.1</td>
<td>4 (9%)</td>
<td>23 (52%)</td>
</tr>
<tr>
<td>P Value</td>
<td>0.2</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
<td>0.4</td>
<td>0.06</td>
<td>0.7</td>
<td></td>
</tr>
</tbody>
</table>

Abstract No. 531

Effectiveness and security of CT-guided percutaneous implantation of radioactive 125 I seeds in T4N2M0 staging pancreatic carcinoma
Z. Liao1, B. Yang2; 1West China Hospital, Chengdu, Chengdu Sichuan; 2West China Hospital, Chengdu, Sichuan

Purpose: To assess the effectiveness and security of CT-guided percutaneous implantation of 125 I seeds in T4N2M0 staging pancreatic carcinoma.

Materials: A total of 13 T4N2M0 staging pancreatic cancer patients (9 males and 4 females) with an average age of 56 years (range, 39–79 years) were enrolled, there were 8 tumors in the pancreatic head and 5 tumors in the pancreatic body or tail. The implantation of 125 I seeds was performed by using 17G coaxial needles (length, 13 mm) through the anterior, lateral and posterior approaches. Then, 125 I seeds were loaded and released into the lesions.

Results: 1–5 punctures were performed for each patient, seeds were implanted with an average of 48.6 (range, 38–126) in patients, and the success rate was 100%. The activity of each seed ranged from 0.6 to 0.8mCi. No procedure-related main adverse event occurred in all patients, only minor events in 5 patients. No significant relationship between the punctures or adverse events was identified. No serious complication was detected after the implantations during follow-up visits. All patients had their pain relieved and 9 (69.2%) patients still survive in 1-year follow-up, four patients died from distant metastases.

Conclusions: This study suggested that CT-guided percutaneous implantation of 125 I seeds in a pancreatic carcinoma was relatively safe and effective for treating T4N2M0 staging pancreatic cancer.

Abstract No. 532

Percutaneous portal vein stent placement: efficacy and predictors of patency: a single-center experience in 27 patients
S. Lekperic1, R. Zhou1, O. Shoaib1, I. Livshits1, J. Loewenstern1, R. Patel1, F. Nowakowski1, R. Lookstein1, A. Fischman1, E. Kim1; 1Icahn School of Medicine at Mount Sinai, New York, NY

Purpose: To evaluate patency of portal vein (PV) stents and identify factors and predictors of stent patency.

Materials: From May 2007 to March 2017, 27 patients (17 males, 10 females, mean age of 60.3, range 37–83) with main PV stenosis successfully treated with percutaneous stent were reviewed. Etiologies included: cholangiocarcinoma (n = 16), OLT stricture (n = 4), HCC (n = 3), gastric cancer (n = 2), colon cancer (n = 1) and surgical injury (n = 1). Overall survival (OS), primary patency (PP, assessed with abdominal Doppler, CT or MRI) and lab values were recorded.

Results: Mean OS was 538.5 days compared to mean PP of 533.3 days (range, for both 18–3758). Splanchnic vein involvement (p = 0.003), Child-Pugh score (p = 0.047), PV occlusions (p = 0.018), age at procedure (p = 0.038), and primary tumor staging (p = 0.045) were all found to be correlates associated with decreased PV stent patency. Specifically, patients with a primary tumor staging greater than 2 experienced decreased PV stent patency (p = 0.0183). Patients with an albumin level greater than 3 g/dL (p = 0.0017), or an alkaline phosphatase level within the normal range of 44–147 U/L (p = 0.0008) at the time of procedure experienced statistically significant longer patency.

Conclusions: PV stent placement is safe with moderate primary patency. Factors associated with decreased patency include splanchnic vein involvement, high Child-Pugh score, PV complete occlusion, and primary tumor component (T) of TNM cancer staging. Albumin and alkaline phosphatase levels at time of procedure are predictive for portal vein stent patency.
Abstract No. 533

Locoregional therapy for the management of hepatocellular carcinoma in adult patients with surgically corrected congenital heart disease

J. Shah1, M. Storace1, R. Ermentrout1, Z. Bercu1, J. Martin1, J. Mitchell1, W. O’Connell1, J. Prologo1, D. Kies1; 1Emory University School of Medicine, Atlanta, GA

Purpose: Surgical advancements in the treatment of cyanotic congenital heart disease (CHD) have improved survival of a previously fatal pediatric ailment. This improved outlook now entails adult management of well-established secondary cardiogenic processes including congestive hepatopathy leading to advanced hepatic fibrosis, portal hypertension, and, rarely, hepatocellular carcinoma (HCC). Due to comorbidities, these patients are usually not candidates for resection; moreover, curative transplantation requiring heart and liver, although feasible, is difficult due to dual organ availability. Thus, management of these cancers with locoregional therapy is an ideal option for these complex patients. Here we describe feasibility and outcomes of yttrium-90 (Y90) transarterial radioembolization (TARE) and percutaneous microwave ablation (MWA) for the treatment of HCC in this unique patient population.

Materials: Between March 2014 and September 2017, 8 patients with CHD and HCC were treated with either percutaneous MWA or TARE. TARE was utilized for patients whose tumors were too large or in a poor location for ablation. 1 patient required TARE and MWA for 2 metachronous lesions. Baseline patient demographics, tumor characteristics, and outcomes including radiologic response, local control, and time to progression were obtained retrospectively.

Results: The average patient age was 27.9 years. In the 8 patients 9 tumors were treated. Median tumor number was 1 and median size was 17 mm. 1 patient was BCLC A, 1 was BCLC C, and 7 were BCLC 0 at time of diagnosis. 5 tumors were treated with MWA, and 4 with TARE. There was a 100% complete response (CR) by mRECIST. The local control rate was 100% with no evidence of local progression. The 1 BCLC C patient had synchronous diagnosis of HCC with a lumbar spine metastasis. While the liver showed CR, extrahepatic disease progressed at 5 months. Median follow-up interval was 174 days.

Conclusions: Percutaneous MWA and TARE are safe and effective treatments for HCC in adult patients with CHD with excellent local control and response rates. Further studies with more patients and longer follow-up periods are needed to assess long-term outcomes, including survival.

Abstract No. 534

Temporary balloon occlusion for hepatic arterial flow redistribution during Y90 radioembolization: a novel technique for treatment of centrally located hepatic tumors

J. Meek1, S. Fletcher1, S. Bezold2, D. Borja-Cacho1, M. Meek1; 1University of Arkansas for Medical Sciences, Little Rock, AR; 2N/A, Little Rock, AR

Purpose: Radiation segmentectomy involves selective intra-arterial Yttrium-90 (Y-90) delivery to hepatic tumors. Centrally located tumors often take blood supply from small branches off main vascular trunks, which makes selective catheterization challenging. We describe a technique in which a distally placed balloon microcatheter was used to temporarily redirect flow into a proximal tumor-feeding vessel for selective Y-90 infusion.

Materials: Five patients were found on angiography to have centrally located tumors with feeding vessels that would be difficult to selectively catheterize. There was a desire to augment tumoral perfusion and decrease exposure of distal non-tumoral parenchyma. During the procedure, the HyperForm balloon (ev3, Medtronic, Minneapolis, MN) was advanced with a .010” Expedion wire distal to the tumoral feeding vessels and a Progreat microcatheter (Terumo Interventional Systems, Somerset, NJ) was advanced into the parent artery proximal to the tumoral vessels. The balloon was inflated, and occlusion of distal vessels was confirmed. Y-90 was infused through the microcatheter. If multiple infusions were necessary, the balloon was deflated after the first administration. A second microcatheter was inserted and the balloon was reinfated for the second infusion. Three patients underwent postprocedural Y-90 PET-CT.

Results: Radioembolization was technically successful in all patients. The average counts and volumes of the target region and entire liver were obtained and multiplied to get the total counts. The percentage of dose deposited in the target region was calculated to be 88%, 91%, and 63% for the three patients who had undergone postprocedural PET-CT. Four patients had undergone follow-up imaging by the time of submission. Contrast enhanced abdominal MRI with modified RECIST criteria was used. There was one complete response, two partial responses, and one stable disease.

Conclusions: We have described the use of a HyperForm balloon placed distal to a tumor feeding artery to temporarily redirect blood flow during Y-90 infusion. In this way, high dose radiation can be delivered directly to a centrally located tumor while sparing a large volume of normal liver parenchyma.

Abstract No. 535

90Y radioembolization of the right inferior phrenic artery in 20 patients with hepatocellular carcinoma

H. Kim1, J. Chung2; 1Seoul National University Hospital, Seoul-City, Seoul; 2Seoul National University Hospital, Seoul, Republic of Korea

Purpose: To address the feasibility and safety of infusion of 90Y glass microspheres directly through the right inferior phrenic artery (RIPA).

Materials: From November 2015 to May 2017, 20 patients underwent 90Y radioembolization through the RIPA. When the systemic-to-pulmonary shunt was demonstrated on C-arm computed tomography (CT) of the RIPA, prophylactic embolization by polyvinyl alcohol (PVA) particles was performed prior to infusion of 90Y glass microspheres. Follow-up medical records and CT scan were retrospectively reviewed for tumor response and possible complications.

Results: Nine (45%) patients had systemic-to-pulmonary shunts on C-arm CT images of the RIPA. The feeder of systemic-to-pulmonary shunt was the azygoesophageal branch (n = 7) and the anterior branch (n = 2). The mean activity of 90Y glass microspheres infused into the RIPA was 0.49 GBq (range, 0.19-1.55 GBq). No patient had radiation pneumonitis or cutaneous complications during follow-up. Seven patients had focal atelectasis (n = 5), focal ground glass opacity (n = 2), and/or small amount of pleural effusion (n = 2) on follow-up image. Tumor response fed by the RIPA was complete response (n = 5), partial response (n = 8), stable disease (n = 4), and progressive disease (n = 3).
Abstract No. 536

Boosted superselective radioembolization may reduce local recurrence in hepatocellular carcinoma patients of BCLC A/B stage
H. Kim1, J. Chung2; 1Seoul National University Hospital, Seoul-City, Seoul; 2Seoul National University Hospital, Seoul, Republic of Korea

Purpose: To address the efficacy of boosted superselective radioembolization with glass microspheres for hepatocellular carcinoma of BCLC A/B stage.

Materials: From March 2016 to April 2017, 28 patients with hepatocellular carcinoma (HCC) were treated by radioembolization with glass microspheres. Inclusion criteria are 1) BCLC stage A or B, 2) nodular tumor, 3) tumor size 3 cm or larger, and 4) Child-Pugh class A. Exclusion criteria are 1) vascular invasion, 2) extrahepatic metastasis, 3) infiltrative tumor, 4) Child-Pugh class B or C, and 5) tumor size less than 3 cm. Study population was divided into standard dose group (less than 180 Gy) and boosted dose group (greater than 180 Gy) according to mean estimated dose of perfused volume. Tumor response was evaluated by mRECIST at 1 month and 3 months after radioembolization. Local recurrence-free survival was analyzed by Kaplan Meier method and compared with log-rank test.

Results: 13 patients had single nodular tumor, and 15 patients had multiple nodular tumor. Mean tumor size is 7.9 cm (range, 3 cm ~ 13.9 cm). Radioactive microspheres were infused into segmental or subsegmental hepatic arteries in most patients, and mean number of vials used is 4.3 (range, 2 ~ 7 vials). Mean activity at administration was 4.17 GBq (range, 1.59 ~ 9.15 GBq). Mean estimated dose of perfused volume was 199 Gy (range, 72 ~ 411 Gy). 16 patients belonged to standard dose group, and 12 patients belonged to boosted dose group. Boosted dose group showed better tumor response than standard dose group (Table). Whereas 6 patients in boosted dose group had local recurrence until August 2017 (p = 0.019).

Conclusions: Boosted superselective radioembolization may reduce local recurrence in HCC patients of BCLC A/B stage.

Abstract No. 537

Comprehensive survival outcomes in a single-center cohort of 501 patients with hepatocellular carcinoma treated with yttrium-90 glass-based radioembolization

D. Biederman1, J. Titano2, R. Korff3, J. Sung4, R. Patel5, F. Nowakowski6, A. Fischman7, R. Lookstein2, E. Kim2; 1Yale School of Medicine, New Haven, CT; 2Icahn School of Medicine at Mount Sinai, New York, NY; 3Albert Einstein College of Medicine, Bronx, NY; 4SUNY Downstate College of Medicine, Fresh Meadows, NY

Purpose: Alpha-fetoprotein (AFP) response has been established as a predictor of radiologic response, time-to-progression, and overall survival compared to chemoembolization in patients with hepatocellular carcinoma and elevated alpha-fetoprotein.

Materials: From 1/2010 to 1/2016, a total of 501 patients (age: 65.9 ± 9.9 years, female: 23.6%) with HCC underwent treatment with glass-based RE. The baseline demographics of the cohort were as follows: age ≤ 65: 243 (48.5%), anti-HCV positive: 302 (60.3%), anti-HBV positive: 85 (17.0%), locoregional therapy (LRT) naïve: 306 (61.1%), ECOG 0: 310 (61.9%), solitary tumor: 180 (35.9%), unilobar distribution: 328 (65.5%), ALBI Grade 1: 35.5%, 2: 59.1%, 3: 5.4%, INR ≤ 1.2: 400 (79.8%), AST toxicity grade (0: 28.3%, 1: 55.9%, 2: 15.8%), platelet count ≥ 100: 189 (37.7%), AFP > 400: 140 (27.9%), PVT present: 125 (25.0%), metastasis present: 42 (8.4%). OS was censored for transplantation. Significant predictors of OS were determined and analyzed using univariate and multivariate analysis. Artificial neural network (ANN) models were constructed to analyze significant predictors of 1-, 2-, and 3-year OS.

Results: Median (95% CI) OS for the cohort was 16.4 (14.2-19.7) months. The median (95% CI) OS in ALBI grade 1 patients and ECOG 0 patients was 28.5 (19.5-) and 20.5 (17.3-25.6) months, respectively. Patients with solitary tumors survived a median of 30.2 (23.1-49.6) months. Multivariate analysis demonstrated more favorable OS in the following sub-groups: ECOG 0: (HR: 1.6, 95% CI: 1.4-2.0, p < 0.001), solitary tumor (HR: 1.5, 95% CI: 1.1-2.0, p = 0.025), ALBI grade (HR: 1.5, 95% CI: 1.2-1.8, p = 0.001), AFP < 400 (HR: 1.5, 95% CI: 1.2-2.0, p = 0.002), absence of PVT (HR: 1.6, 95% CI: 1.3-2.2, p <0.001), and absence of metastasis (HR: 1.6, 95% CI: 1.1-2.4, p = 0.013). The 1-, 2-, and 3-year OS rates across the entire cohort were 63%, 38%, and 28%, respectively. ANN modeling demonstrated ECOG, ALBI grade, presence of PVT, and prior LRT as variables of high importance in predicting 1-year OS. ALBI grade was the variable of greatest importance in predicting 2- and 3-year OS.

Conclusions: This study provides a comprehensive analysis of survival outcomes in a single-center cohort of 501 patients with HCC treated with RE.
overall survival (OS) in patients with hepatocellular carcinoma (HCC). We present a novel, time-variying analysis of posttreatment AFP levels to compare the efficacy of chemoembolization (TACE) and radioembolization (RE) in the treatment of patients with HCC.

**Materials:** From 1/2010 to 1/2016, a total of 233 and 152 patients with HCC and pretreatment AFP > 200 ng/mL were treated with TACE and RE, respectively. Including patients who were RE and TACE treatment naive without portal vein invasion or extra-hepatic metastasis yielded a cohort of 183 patients (age: 65.0 ± 10.9 years; female: 29.0%; TACE: 72.1% RE: 27.9%). The following outcome variables were analyzed: laboratory toxicities, AFP response, time-to-AFP-progression (TTP-AFP), time to secondary therapy (TTST), and OS. The technique of propensity score stratification (PSS) was used to adjust for confounding.

**Results:** AFP response at a 50% reduction threshold was 62% in the TACE group and 76% in the RE group (p = 0.07). AFP response was more favorable in the RE group at the 75% (TACE: 49%, RE: 67%, p = 0.036) and 95% (TACE: 20%, RE: 37%, p = 0.015) reduction thresholds. The median TTP-AFP was 84 (67-112) days in the TACE group and 159 (91-253) days in the RE group (HR: 0.54, 95% CI: 0.37-0.81, p = 0.003). Patients in the RE group were less likely to undergo additional locoregional therapy (HR: 0.27, 95% CI: 0.17-0.43, p<0.001). Censoring for additional treatments accentuated the difference in AFP response (50%: p = 0.026, 75%: p = 0.011, 95%: p = 0.011) and TTP-AFP (p<0.001) outcomes favoring the RE group. The median OS (months) was 14.9 in the TACE group and 23.1 in the RE group (HR: 0.58, 95% CI: 0.35-0.96, p = 0.035). OS was highly correlated with AFP response (p<0.001) across the entire cohort. These aforementioned differences were maintained after PSS as follows: TTP-AFP: p = 0.004, TTST: p<0.001, AFP response (50%: p = 0.079, 75%: p = 0.045, 95%: p = 0.008), and OS: p = 0.034.

**Conclusions:** RE results in improved efficacy and OS compared to TACE in patients with unresectable HCC and elevated AFP.

---

**Abstract No. 540**

**Correlation of pretreatment **$^{99m}$**Tc-mebrofenin hepatobiliary scintigraphy with clinical status prior to hepatic radioembolization**

M. Ertreo¹, S. Chowdhury¹, J. An², T. Cardeli¹, G. Lynskey¹, D. Buckley¹, E. Cohen¹, J. Cardella¹, D. Field¹, J. Spies¹, A. Kim¹; ¹MedStar Georgetown University Hospital, Washington, DC; ²National Institutes of Health, Bethesda, MD

**Purpose:** To correlate scintigraphic hepatobiliary $^{99m}$Tc-mebrofenin uptake ratio with baseline clinical status and liver function to evaluate its utility as an adjuvant indicator of liver function in patients undergoing Y90-radioembolization (RE).

**Materials:** Single-center retrospective review of patients with hepatobiliary $^{99m}$Tc-mebrofenin scan prior to RE for primary or secondary liver malignancy from July 2015 to September 2017. Regions of interest for mebrofenin uptake were drawn over the entire liver from July 2015 to September 2017. Regions of interest for mebrofenin uptake were drawn over the entire liver and heart. Corrected mebrofenin uptake ratio (cMUR) was calculated as%uptake/min/BSA (body surface area).

Pre-RE cMUR was correlated with prior chemo- and interventional therapies, pre-RE total bilirubin, albumin and INR values, ECOG status, MELD, ALBI, and Child-Pugh scores using Spearman’s rank correlation test. Significance was considered at p<0.05. Multivariate regression was not performed due to small sample size. Results are presented as median and interquartile range.

**Results:** 22 patients were included, of which 11 (50%) had hepatocellular carcinoma and the remaining metastatic disease. 6 (30%) patients had cirrhosis. At baseline, 16 (76%) patients had received 1 (1-2) line of chemotherapy, 5 (23%) had prior TACE, 4 (18%) prior RFA and 2 (9%) prior RE. No patients had ascites or jaundice at baseline. Pre-RE cMUR was 6.32%uptake/min/m² (5.04-8.33). Total bilirubin, albumin, and INR were 0.65 mg/dl, 7.4 mg/dl, and 1.0 respectively.

---

**Abstract No. 539**

**Total burden of liver tumor: poor prognostic factor for survival and treatment response following Y90 radioembolization of hepatic metastases and cholangiocarcinoma**

S. Haider¹, D. Xu¹, M. Chervonski¹, R. Widomon¹, C. Cooper¹, J. Weintraub¹, A. Kim¹; ¹NewYork Presbyterian/Columbia University Medical Center, New York, NY

**Purpose:** Investigate the effect of total liver tumor volume on survival and treatment response following Y90 radioembolization (TARE) for liver metastases and cholangiocarcinoma.

**Materials:** Retrospective review of patients treated with TARE at our institution between January 2015 and January 2017 was performed. Primary outcome was overall survival (OS) after TARE. Secondary outcome was RECIST 1.1 criteria treatment response assessed loco-regionally. Total liver tumor and parenchymal volumes segmented volumetrically on pre-TARE contrast-enhanced CT or MR imaging. Outcomes were adjusted for age, cancer type, extra-hepatic disease, hepatic resection and TARE as salvage treatment. Cox proportional hazards models were fitted to the data and Kaplan-Meier curves were drawn.
outperformed RECIST 1.1 size criteria in predicting survival. The therapeutic objective of radioembolization should be radiologic response and not solely to prevent progression.

Abstract No. 542
Survival analysis of 79 patients with advanced hepatocellular carcinoma treated with Y90
H. Kocharyan1, A. Rastegarpour2, C. Bailey3, A. Sucher4, L. Karapetyan5, O. Intikhab6, J. Critchfield1; 1DMC, Lansing, MI; 2Wayne State University/Detroit Medical Center, Detroit, MI; 3Wayne State University/Detroit Medical Center, Brighton, MI; 4N/A, Berkley, MI; 5Michigan State University, Lansing, MI; 6Wayne State University/Detroit Medical Center, Warren, MI; 7Karmanos Cancer Institute, Troy, MI

Purpose: We present the survival data of nine year experience of Y90 treatments for advanced HCC performed at Detroit Medical Center.

Materials: Retrospective survival analysis of all patients treated with Y90 Therasphere for advanced HCC was done from 2008 to 2016 at Detroit Medical Center. Out of 96 patients 79 had data available for the overall survival calculated from the date of the treatment to the date of death or present date. The data analysis was performed with SPSS package using survival analysis with Kaplan-Meier and Log rank tools.

Results: Survival data was obtained from 79 patients with HCC undergoing treatment with Y90 therasphere embolization. The median survival was estimated to be 330.0 days (95%CI:217.8-368.2) for Barcelona stage C patients. One of the median survival of 330.0 ± 61.6 days (p = 0.640). Barcelona scores significantly affect the survival outcomes. Out of 79 patients, 20 (25.3%) had a history of Sorafenib chemotherapy with a median survival of 306.0 ± 168.4 days. Patients that did not have a history of Sorafenib chemotherapy demonstrated a median survival of 330.0 ± 61.6 days (p = 0.640). Barcelona scores were available for 79 patients; 23 were stage B, 54 were stage C, and 2 were stage D. The median survival was 494.0 ± 190.4 days (95% CI:120.8-367.2) for Barcelona stage B patients and 293.0 ± 38.4 days (95% CI:217.8-368.2) for Barcelona stage C patients. One of the stages D patients died 92 days after the treatment and the other one was alive at the time of the analysis.

Conclusions: Our survival results after Y90 Therasphere are comparable to the previously reported data and confirm the survival benefit of Y90 in non resectable HCC patients.

Abstract No. 543
Transarterial radioembolizatation hepatic biochemical safety analysis as a function of percent liver treated and administered dose
J. Shah1, B. Geller2, C. Meiers1, A. Kolarich3, C. Alvarado4, M. Wang3, C. Iv3, A. Lubinski3, L. Thornton1, A. Ahmed1, S. Wiley4, M. Kapp1,

Radiologic response as a potential surrogate endpoint to overall survival in hepatocellular carcinoma patients undergoing radioembolization
A. Gabr1, A. Riaz2, R. Ali3, N. Abouchaleh4, R. Mora5, A. Al Asadi6, S. Mouli7, R. Lewandowski8, R. Salem9; 1Northwestern University Feinberg School of Medicine, Chicago, IL; 2Northwestern Medicine, Chicago, IL; 3Northwestern University, Forest Park, IL; 4Northwestern University, Chicago, IL; 5N/A, Chicago, IL

Purpose: To study the ability of post-radioembolization imaging response to predict overall survival in hepatocellular carcinoma (HCC).

Materials: With IRB approval, we searched our prospectively acquired HCC database. 948 patients with HCC were treated with radioembolization (Y90) from 2003-2016. Patients with baseline metastases, vascular invasion, multifocal disease, Child-Pugh (CP) >B7, and transplanted/resected were excluded. This created our homogeneous study cohort of 134 patients with CP ≤B7 and solitary HCC. Response (using European Association for Study of the Liver [EASL] and Response Evaluation Criteria in Solid Tumors 1.1 [RECIST 1.1] criteria) was correlated with survival using Landmark and risk-of-death methodologies after reviewing 960 scans. Patients who showed complete or partial response to treatment at specific landmarks were considered as responders. In a subanalysis, survival times of responders were compared to those of patients with stable disease (SD) and progressive disease (PD). Uni/multivariate survival analyses were performed at each Landmark.

Results: At the 3-month landmark, responders survived longer than nonresponders by EASL (hazard ratio [HR], 0.46; confidence interval [CI], 0.26-0.82; P = 0.002) but not RECIST 1.1 criteria (HR, 0.70, CI, 0.37-1.32; P = 0.32). At the 6-month Landmark, responders survived longer than nonresponders by EASL (HR, 0.32; CI, 0.15-0.77; P < 0.001) and RECIST 1.1 criteria (HR, 0.50; CI, 0.29-0.87; P = 0.021). At the 12-month Landmark, responders survived longer than nonresponders by EASL (HR, 0.34; CI, 0.15-0.77; P < 0.001) and RECIST 1.1 criteria (HR, 0.52; CI 0.27-0.98; P = 0.049). At 6 months, risk of death was lower for responders by EASL (P < 0.001) and RECIST 1.1 (P = 0.0445). In subanalyses, responders lived longer than patients with SD or PD. EASL response was a significant predictor of survival at 3-, 6-, and 12-month Landmarks on uni/multivariate analyses.

Conclusions: Response to Y90 in patients with solitary HCC can prognosticate improved survival. EASL necrosis criteria

3.55 g/dL, and 1.1, respectively. Pre-RE cMUR was not significantly associated with any pre-RE clinical factors or interventions, although prior RFA showed a slight trend for decreased cMUR (p = 0.08). Pre-RE MELD, ALBI, ECOG and Child-Pugh were not statistically associated with cMUR either. Total bilirubin was the only liver function test that correlated significantly with cMUR (p = 0.0041).

Conclusions: In this limited analysis, pre-RE cMUR inversely correlated only with pre-RE total bilirubin levels. Results could have been hindered by a relatively healthy population and small cohort. Further studies are needed to evaluate its application in patients with decreased liver function to help improve identification of optimal RE candidates.
G. Gilbride1, S. Bozorgmehr1, J. Grajo1, B. Toskich5; 1University of Florida, Gainesville, FL; 2N/A, Gainesville, FL; 3University of Florida College of Medicine, Gainesville, FL; 4N/A, United States; 5Mayo Clinic, Atlantic Beach, FL

Purpose: To evaluate hepatic biochemical safety after Yttrium-90 transarterial radioembolization (TARE) for primary & metastatic hepatic malignancies as a function of % liver treated & administered dose.

Materials: An IRB approved retrospective study of patients with hepatic malignancies treated with TARE from 2013 to 2017 was performed. Included patients had pre- and post-TARE labs (1-3 months), pre-TARE cross-sectional imaging, & post-TARE clinic follow-up (FU). 216 out of 282 patients met inclusion criteria. Patient demographics, tumor type, HCC risk factors, previous systemic & locoregional therapies were analyzed. Na-MELD & ALBI scores were calculated pre- and post-TARE. Patients were analyzed in 2 groups: % liver treated (<25, 25-49, 50-74, ≥75) [30,61,106,19 patients] & administered dose (Gy) using MIRD methodology (<120, 120-189, ≥190) [36, 148, 32 patients]. Uni & multivariate analyses using linear & logistic regression models were performed.

Results: 149 males & 67 females with a mean FU of 322 days were evaluated. 158 (73%) patients had primary malignancy & 58 (27%) had metastatic cancer. Cirrhosis (50%) & hepatitis C (44.4%) were the main risk factors. Pre-TARE locoregional therapies included TACE (12.5%) & microwave ablation (12%). 135 patients had pre-TARE systemic therapy. Mean pre-TARE Na-MELD & ALBI scores were 10.1 & -2.5, respectively. There was a statistically significant difference (SSD) in pre- and post-TARE Na-MELD scores in the% liver treated group on uni & multivariate analyses (p = 0.029 & 0.043 respectively). The mean difference between pre & post TARE Na-MELD scores on univariate analysis was 0.08 for <25% group, 1.22 for 25-49%, 1.32 for 50-74% & 3.4 for >75%. The mean dose (Gy) for <25% group was 256.7 (range, 115-540), 25-49% was 153.3 (85-455), 50-74% was 129.3 (93-454) & >75% was 129.6 (67-186). There was no SSD in the pre- and post-TARE Na-MELD in administered dose group. There was no SSD in the pre- & post-TARE ALBI scores in both groups.

Conclusions: Hepatic biochemical safety as determined by Na-MELD score was only affected when >75% of the liver was treated. Administered dose did not affect Na-MELD or ALBI scores. Clinical adverse events and survival will be analyzed for both groups in future studies.

Abstract No. 544

Radioembolization for metastatic colon cancer: survival differences between right- and left-sided primary sites

K. Singh1, J. Savin1, M. Savin2, C. Wong3; 1Beaumont Health, Royal Oak, MI; 2Oakland University William Beaumont School of Medicine, Royal Oak, MI; 3University of Southern California, Sacramento, CA

Purpose: For patients with unresectable colon cancer liver metastases (mCRC), in addition to chemotherapy, interventional radiology procedures may be considered, including radioembolization (RE). A recent multicenter randomized controlled trial of 1st line chemotherapy with or without RE suggested a survival benefit for RE for right-sided but not for left-sided mCRC (1). Further, survival is significantly longer in mCRC patients with primary tumors originating in the left colon compared to the right (2). The purpose of this study is to determine if there is a survival difference in patients with right versus left-sided mCRC treated with RE.

Materials: A retrospective study was performed of 80 consecutive mCRC patients with liver-only or liver-dominant metastases not suitable for surgery or ablation treated with RE between July 2002 and November 2011. Data collected from medical and public records included demographics, dates of diagnosis, RE and death.

Results: Of 80 patients, 37 had left-sided and 29 right-sided primaries with 10 rectum, and one anorectal, multiple, mid-transverse and unknown. Two patients were alive at the end of follow-up. Overall median survival was 9.0 months from RE and 30.9 mo from colon cancer diagnosis. Median survival from first RE was longer for left (12.1 mo) vs right (6.1 mo) primary sites (p = 0.026). Median survival from diagnosis for left (33.5 mo) vs right (27.0 mo) was not significantly different (p = 0.524). At time of first RE, there were no significant left vs right primary site differences in age, gender, presence of extrahepatic tumor, number of lines of prior chemotherapy, performance status, and tumor-to-liver volume ratio.

Conclusions: Following RE, mCRC patients with left-sided primaries had longer median survival than those with right-sided primaries. This difference was not accounted for by differences in other patient or tumor characteristics. These data add to literature describing the impact of primary tumor location on mCRC outcomes and may support a side-based approach to RE treatment selection.

Abstract No. 545

Factors affecting residual catheter hub radioactivity during intrahepatic delivery of 90Y TheraSphere

P. Massa1, M. Pilat1, N. Bevins1, M. Vanderhoek3, S. Schwartz1, T. Getzen1; 1Henry Ford Hospital, Detroit, MI

Purpose: Given the complexity and cost of intrahepatic 90Y TheraSphere radioembolization including pretreatment mapping, dose planning, dose ordering/delivery and finally treatment, it is paramount that the optimal dose of radiation is deposited in the intended tumor. During treatments, great care is taken with the delivery system to optimize safety and overall efficacy of the radioembolization. An ongoing quality control at our institution is the measurement of residual activity within the catheter hub and delivery system during each treatment. We reviewed several factors regarding 90Y TheraSphere delivery to determine which, if any, play a role in residual activity that remains in the delivery system and catheter.

Materials: Retrospective review of 39 of the most recent 90Y TheraSphere treatments at our institution was performed. Data was collected and analyzed including overall dose, authorized user pushing the dose, catheter used, volume of liver being treated, and peak RO-7 hub readings during injection and after flushing.

Results: Overall average final residual activity in the catheter hub for all treatments was 3.3 (R/h), subset of treatments that used a
ProGreat catheter was 6.1 (R/h) (n = 19), and subset of treatments that used a Renegade HI-FLO catheter was for was 0.6 (R/h) (n = 20). This difference was found to be statistically significantly different with a p-value < 0.001. Residual activity in the catheter hub was not found to correlate with the authorized user pushing the dose, overall dose delivered (r = -0.05), or liver volume treated (r = -0.01).

**Conclusions:** The type of microcatheter used for the $^{90}$Y injection was found to have a statistically significant impact on the amount of residual radiation in the catheter at the end of treatment. This is theorized to relate to differences in design of the catheter and specifically, the catheter hub, which is connected to the standard TheraSphere delivery tubing. The other studied factors that conceivably could play a role in residual radioactivity in the catheter hub were not found to have a significant correlation.

---

**Abstract No. 546**

**Patterns of extrahepatic spread in hepatocellular carcinoma patients with portal vein thrombosis treated with radioembolization**

A. Rasheed, A. Gabr, R. Ali, R. Mora, N. Abouchaleh, A. Al Asadi, S. Mouli, R. Riaz, R. Lewandowski, R. Salem, N/A, Huntley, IL; Northwestern University Feinberg School of Medicine, Chicago, IL; Northwestern University, Forest Park, IL; N/A, Chicago, IL; Northwestern University, Chicago, IL; Northwestern Medicine, Chicago, IL

**Purpose:** To assess the pattern of development of metastases in patients who underwent Y90 radioembolization (Y90) for hepatocellular carcinoma (HCC) and malignant portal vein thrombosis (PVT).

**Materials:** With IRB approval, we searched our prospectively acquired database (2004-2017). Inclusion criteria were a) patients with PVT who were treated with Y90 and b) had imaging follow-up. Post-Y90 imaging follow-up included radiographs, ultrasound, and/or cross-sectional imaging for chest/abdomen/pelvis/bones/brain. Patients were stratified by location of metastases. Time to development of first metastatic lesion and overall survival (OS) were calculated using Kaplan-Meier analysis.

**Results:** 150 patients met the inclusion criteria. Out of these, 48 (32%) developed metastatic lesions following Y90. Sites for first metastases were lung (15/48), lymph node (8/48), peritoneal (5/48), adrenal (3/32), bone (2/48) and (15/48) developed simultaneous metastases to multiple sites. Median time (95% CI) to development of metastases for entire cohort was 40 months (15.4-40). In the 48 patients who developed metastases, median time (95% CI) to first metastatic lesion was 2.4 months (0.4-40). Median OS (95% CI) for entire cohort was 7.7 months (6.5-9.5). Median OS (95% CI) for patients who developed metastases was 6.9 (4.6-11.4) months vs 8.0 (6.4-11.1) months for patients who did not have metastases (P = 0.31).

**Conclusions:** Development of metastases is a common finding among patients with advanced stage HCC and malignant PVT with lung being the most common site. Given that time to metastatic development is 40 months while OS was 7.7 months, it can be inferred that death from liver disease is the most likely cause of death in such patients.

---

**Abstract No. 547**

**Radioembolization segmentectomy and stereotactic body radiation therapy for hepatocellular carcinoma: a retrospective survival analysis**

J. Gans, S. Lerman, N. Ohri, R. Kabarriti, Y. Golowa, J. Cynamon, R. Moadel; Montefiore Medical Center, Bronx, NY; Albert Einstein College of Medicine, Bronx, NY

**Purpose:** To compare outcomes among hepatocellular carcinoma (HCC) patients treated with radioembolization segmentectomy (RS) with yttrium-90 conjugated beads or stereotactic body radiation therapy (SBRT).

**Materials:** This single-center retrospective study included all HCC patients treated with RS or SBRT from January 2010 to February 2016. Records were reviewed for sex, median age (MA), target tumor size (cm) (TS), prior local-regional therapy with transarterial chemoembolization and/or ablation (LRT), radiographic response progression, and overall survival time (OST). Kaplan Meier and Cox multivariate regression survival analysis were performed to determine time to local progression (TLP), time to overall disease progression (TOP), and OST (months) after RS or SBRT along with hazard ratio (HR). There were 51 RS patients (75% male, MA 66) and 71 SBRT patients (75% male, MA 64) included. When TS was restricted to ≤5 cm, there were 23 RS patients (78% male, MA 64) and 64 SBRT patients (72% male, MA 65).

**Results:** Kaplan Meier revealed for all RS and SBRT respectively: TLP (34.6 v 54.8, p<0.04), TOP (19.1 v 27.6, p = 0.15), and OST (33.4 v 55.6, p = 0.48). Mean TS for RS and SBRT was 5.4 v 3.4, p<0.01. Rates of prior LRT in RS and SBRT were 25% v 87% (p<0.01). Multivariate regression survival analysis including treatment type, sex, age, prior LRT, and TS (Table 1) demonstrated that TS was the only independent predictor of TLP, TOP, and OST. When TS for RS and SBRT was limited to ≤5 cm (mean TS 3.3 v 2.6, p = 0.13), Kaplan Meier revealed respectively: TLP (39.3 v 55.6, p = 0.47), TOP (25.3 v 27.4, p = 0.83) and OST (38.3 v 50.0, p = 0.92).

**Conclusions:** Retrospective analysis demonstrates RS and SBRT have similar outcomes in HCC with TS ≤5 cm and the majority of SBRT patients had prior LRT. TS may be an important factor in selecting RS and SBRT with LRT.

<table>
<thead>
<tr>
<th>Table 1. Cox Regression Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RS v SBRT</strong></td>
</tr>
<tr>
<td>0.4(0.14)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
</tr>
<tr>
<td>0.3(0.11)</td>
</tr>
<tr>
<td>0.6(0.16)</td>
</tr>
<tr>
<td>1.0(0.47)</td>
</tr>
<tr>
<td><strong>TS</strong></td>
</tr>
<tr>
<td>1.2(≤0.01)</td>
</tr>
<tr>
<td>1.3(≤0.01)</td>
</tr>
</tbody>
</table>

**Abstract No. 548**

**A score based on routine laboratory values as a prognosticator of survival in hepatocellular carcinoma**

R. Ali, Y. Yang, A. Gabr, N. Abouchaleh, A. Al Asadi, R. Mora, S. Mouli, R. Lewandowski

**Purpose:**

A score based on routine laboratory values as a prognosticator of survival in hepatocellular carcinoma.
Purpose: To investigate laboratory parameters as predictors of overall survival (OS) for hepatocellular carcinoma (HCC) treated with yttrium-90 radioembolization (Y90) and develop/validate a prognostic scoring system.

Materials: With IRB approval, we selected all patients that underwent Y90 for HCC with baseline alpha-fetoprotein (AFP) > 100 ng/dl from our prospectively acquired database. Laboratory values [neutrophil-lymphocyte (N/L) (inflammatory-immune response), albumin-bilirubin (ALBI) grade (liver function), and AFP (tumor marker)] were measured at baseline and at 1-, 3-, and 6-month post-Y90 Landmarks. OS was assessed from these Landmarks. Univariate/multivariate analyses were performed to evaluate OS predictability of these parameters. Three scoring systems were developed [Baseline Imaging Score (including PVT, metastases, ascites, portal hypertension); Laboratory Score (including ALBI and AFP)]. We divided patients into two groups (Predicting Group and Validating Group) to investigate and validate the predictability of these scoring systems. Time-dependent receiver operating characteristics (ROC) were evaluated.

Results: 345/401, 238/401, and 167/401 patients had laboratory parameters available at 1-, 3-, and 6-month Landmarks, respectively. ALBI score and AFP response were significant predictors of OS. Laboratory Score [ALBI+(0.3 × LnAFP)] was developed to predict OS from these Landmarks in the Predicting Group and was internally validated. Areas under the curve (AUC) of the Laboratory Score in predicting OS of laboratory parameters and imaging response was developed/validated. This Laboratory Score (simple objective metric) was included in this analysis. Then, we assessed imaging response using a) Response Evaluation Criteria in Solid Tumors (RECIST), b) World Health Organization (WHO), c) European Association for Study of the Liver (EASL) and d) modified RECIST (mRECIST) at baseline and 1-, 3-, and 6-month post-Y90 Landmarks. OS was assessed from these Landmarks using univariate analyses and multivariate Cox regressions. A Combination Score of laboratory parameters and imaging response was developed. Time-dependent receiver operating characteristics were evaluated.

Conclusions: Combining the Laboratory Score and mRECIST response improves post-Y90 OS prognostic ability. This information is helpful in prognostication of survival in patients with HCC.
Results: 223 HCC patients with macrovascular invasion underwent 361 Y90 treatments (2004-2017). 190 patients (85%) presented solely with PVT while 5 patients (2%) had HVT alone. 28 patients (12.6%) had PVT with HVT. Median age was 64 years (range, 26-89); 147 (66%) were male. 125 patients (56%) presented with unilobar tumors. Child-Pugh class categories were A, B, and C in 92 (41.3%), 122 (54.7%), and 9 (4%) patients, respectively. Regarding LSF, 56 patients (25%) had LSF > 15% while 167 (75%) had LSF < 15%. Only HVT was found to be significantly associated with high LSF in logistic regression model (P = 0.01). Mean LSF for the cohort was 8.6% (range, 0.6%-57%). Statistically significant difference was shown comparing the LSF means between patients presenting with PVT solely (10.5%) versus patients with HVT alone (15.0%) (P = 0.013). In the 190 patients with PVT only, patients with and without portal hypertension did not demonstrate a difference in LSF (P = 0.170). OS for patients with HVT (median 8.7 months, 95% CI: 5.3-11.0) was not significantly different in comparison to patients with no HVT (median 7.7 months; 95% CI: 6.4-8.8) (P = 0.54).

Conclusions: In HCC presenting with macrovascular invasion, only HVT was correlated with LSF > 15%. HVT was associated with poor prognosis in HCC patients undergoing Y90.

Abstract No. 551

Comparison of 2- and 1-day hepatic Y-90 radioembolization protocols using time-driven activity-based costing analysis
A. Cahalane1, R. Liu1, S. Shah2, S. Ganguli3; 1Massachusetts General Hospital, Boston, MA; 2Johns Hopkins Medical School, Baltimore, MD; 3Massachusetts General Hospital/Harvard Medical School, Boston, MA

Purpose: Transarterial radioembolization (RE) with Yttrium 90 (Y90) is increasingly being incorporated into treatment algorithms for unresectable hepatic malignancy, from its initial use in the treatment of colorectal metastatic disease to its current use in varying metastatic disease processes. RE has traditionally been considered a two-day (TD) procedure with initial mapping angiography and Technetium-99m macroaggregated albumin (MAA) scintigraphy performed to confirm target vessel selection and determination of Y90 dose. Costs associated with traditional RE include radiopharmaceuticals, scintigraphy and the requirement for two procedure room sessions. Recently, a novel one day (OD) RE protocol has increasingly been utilized. In this study, we aimed to assess the financial impact of converting from the traditional TD RE protocol to the new OD protocol using time-driven activity-based costing analysis (TDABC), an approach to cost analysis which integrates process mapping and resource consumption per unit of time data.

Materials: Following TDABC protocol, process maps of expenses for each stage of TD and OD RE were developed. These time estimates were verified through retrospective medical records and direct observation over a 2-month period. Capacity cost rates were subsequently obtained from actual costs incurred for each procedure by each resource. Capacity cost rates multiplied by individual process times enabled the calculation of the total costs for each procedure.

Results: OD RE costs are 95% of those associated with TD RE based on TDABC analysis. Consumable costs account for approximately 81% of the TD RE protocol and 86% of the OD protocol. The largest component of the consumable expenses is the Y90 dose, which accounts for 72% of the TD RE protocol expenses, and 76% of the OD RE expenses. The remaining percentages are accounted for by personnel and equipment/building costs.

Conclusions: Despite transitioning to a OD protocol, procedure costs are minimally reduced for Y90 RE, primarily due to the fixed cost of the Y90 dose itself. This emphasizes the importance of accurate cost analysis to identify achievable efficiencies from all perspectives to optimize healthcare provision.

Abstract No. 552

Does echocardiogram have utility in the management of pericardial drains in patients with malignant or inflammatory pericardial effusions? S. Rice3, H. Yarmohammadi2, 1Memorial Sloan-Kettering Cancer Center, Forest Hills, NY; 2Memorial Sloan-Kettering Cancer Center, New York, NY

Purpose: Evaluate the role of echocardiographic imaging in the management of pericardial drains placed for treatment of symptomatic pericardial effusion.

Materials: Search of the medical record was performed to identify all patients (n = 51; 24 male and 27 female; age range 23-84 mean 56.65) who underwent image-guided placement of a pericardial drain (PD) at a single institution by interventional radiology (IR) between January 2015 and June 2017. 42 patients were included in our study with exclusion of 5 patients who died with the drain in place, 2 patients who required subsequent pericardial window, and 2 patients with drain malfunction requiring premature repositioning or removal. Cytology was sent for 34 of the included patients and was positive for malignant cells in 16 samples. Echocardiograms (ECHO) were ordered at the discretion of the primary medical or surgical team. IR utilized our standard institutional policy for pericardial drain management with removal of a drain after output is less than 50 cc for 24 hours, ECHO results were appreciated prior to removal when available.

Results: 32 patients had an ECHO performed after placement of the PD, 18 were performed the day prior to, or the day of drain removal. 10 patients did not have an ECHO result available prior to drain removal. The mean time for drain removal was 4.6 days (1-11 days. Median 4 days). Mean output over the preceding 24 hours prior to drain removal was 17.3 cc (0 cc-50 cc). No patients required repeat drainage of the pericardium after drain removal.

Conclusions: Post PD ECHO results all demonstrated a substantial decrease or complete resolution of the effusion post insertion, even when drain output remained high. After PD placement the assessment of residual pericardial fluid with ECHO is unnecessary for the management of drain removal in both malignant and inflammatory pericardial effusions. We demonstrated the utilization of drain output < 50 cc per 24 hours and resolution of clinical symptoms are accurate and appropriate marker for management of PD removal. Given the cost in both healthcare resources and dollars for performing ECHO examination we recommend forgoing this procedure in the management of PD removal.
Abstract No. 553

Percutaneous drainage of peri-mesh collections following ventral hernia repair: a single institution’s experience with 55 patients
K. Lahiji1, P. Kavali1, R. Ramaswamy1, N. Mani1;1Mallinckrodt Institute of Radiology, St. Louis, MO

Purpose: The purpose of this study is to evaluate the efficacy of percutaneous drainage for the treatment of infected mesh following ventral hernia repair (VHR).

Materials: A retrospective analysis was performed evaluating patients who underwent percutaneous drainage of peri-mesh complications following ventral hernia repair (VHR) at a single institution from July 1, 2010, to July 1, 2015. In addition to demographic data, the number of fluoroscopic-guided catheter evaluations/changes were recorded. The end-point of our data collection was either drainage catheter removal or mesh explantation. Catheter removal was typically performed in asymptomatic patients whose drainage output was below 10 cc per day. Exclusion criteria included lost to follow-up, transfer of care to another facility, or use of sclerosing materials.

Results: 69 cases of percutaneous drainage following ventral hernia repair with mesh were evaluated (27 men, 42 women, mean age 46.7 years). A total of 14 patients were excluded due to loss to follow-up (n = 5), transfer of care (n = 2), and use of sclerosant therapy as this is not the standard of care (n = 7). 55 patients were subsequently analyzed who had a total of 67 catheters placed (1.2 catheters per patient, range 1-3). Types of mesh included biologic/fully absorbable (n = 29), polypropylene (n = 23), and polytetrafluoroethylene (PTFE) (n = 3). The average catheter dwell time was 36.6 days with an average of 2.1 checks and/or changes per catheter placed. Mesh was salvaged in 42 of the 55 patients 76.4% with percutaneous drainage alone. 7 patients additionally underwent open incision, drainage, and washout of the collections with an overall salvage rate being the most common organism. Clinical success, as defined by resolution of the fluid collection and preservation of the pancreatic allograft, was achieved in 25 of 30 patients (83%). Despite percutaneous drainage, five patients (17%) required pancreatectomy. Three of these five patients had a subjacent peritoneal abscess collection, which may have led to drainage failure. No procedurally related adverse events occurred. There was no significant difference in age or gender between patients with clinical success and failure.

Conclusions: Percutaneous drainage is an effective technique for the treatment of peripancreatic fluid collections following pancreas transplantation, maintaining graft function, and reducing the need for surgical intervention.

Abstract No. 554

Clinical outcomes of peripancreatic drainage following pancreas transplantation
J. Knox1, E. Watson2, P. Gonzales3, N. Fidelman3, M. Kohi1, 1UCSF School of Medicine, San Francisco, CA; 2Sidney Kimmel Medical College at Thomas Jefferson University, Philadelphia, PA; 3UCSF Department of Radiology, San Francisco, CA

Purpose: Peripancreatic fluid collections are a common complication of kidney-pancreas transplantation associated with high risk of infection and graft failure (1,2). Therefore, we sought to determine the clinical outcomes of percutaneous drainage of peripancreatic collections following pancreas transplantation at our institution.

Materials: A retrospective review of patients who underwent drainage of peripancreatic fluid collections following pancreatic transplantation between January 2001 and August 2017 was performed. 30 patients underwent percutaneous drainage catheter placement (67% male; median age 45 years, range 30-52). Patient demographics, surgical technique, microbiology analysis and clinical outcomes were reviewed.

Results: The median time between pancreas transplantation and percutaneous drainage was 280 days (range, 8-3401 days). The peripancreatic drains were left in place for a median of 28 days (range, 4-226 days). Microbiology analysis of fluid collections revealed growth in 15 of 30 (50%) patients, with Escherichia coli being the most common organism. Clinical success, as defined by resolution of the fluid collection and preservation of the pancreatic allograft, was achieved in 25 of 30 patients (83%). Despite percutaneous drainage, five patients (17%) required pancreatectomy.

Conclusions: Clinical outcomes of peripancreatic drainage following pancreas transplantation were related to infection, radiographic findings, and overall clinical outcomes. The majority of patients achieved clinical success, but the need for surgical intervention for persistent collections remained a challenge.

Abstract No. 555

Argon CleanerXT thrombectomy device augmentation of active percutaneous pancreatic necrosectomy
E. DePopas1, P. Rochon2, M. Brown3, D. Johnson4, J. Lindquist5, K. Kondo6, K. Schramm7, R. Ryu8, 1University of Colorado Anschutz Medical Campus, Aurora, CO; 2University of Colorado School of Medicine, Denver, CO; 3University of Colorado Hospital, Aurora, CO; 4University of Colorado Denver, Centennial, CO; 5University of Colorado Anschutz Medical Center, Aurora, CO; 6University of Colorado, Aurora, CO; 7University of Colorado, Denver, CO; 8University of Colorado Denver, Aurora, CO

Purpose: Infected pancreatic necrosis (IPN), carries a 20-40% mortality risk despite current surgical therapies 1–3. Although minimally invasive active debridement techniques exist – aggressive pancreatic lavage, snare, and Dorima basket fragmentation – up to 50% of patients eventually require surgical necrosectomy due to incomplete removal of infected tissue 4. The aim of this retrospective study was to evaluate outcomes in patients who received a new, augmented form of active pancreatic necrosectomy with the Argon CleanerXT Thrombectomy Device.

Materials: The study included individuals from 2015-2017 diagnosed with IPN who received augmented active pancreatic necrosectomy secondary to failure of passive percutaneous drainage (n = 6). Major study endpoints included patient mortality and need for subsequent surgical necrosectomy. An Unpaired t-test and Mann Whitney test were used to compare the outcomes in patients treated with augmented necrosectomy versus previously reported outcomes in patients treated with traditional active pancreatic necrosectomy (n = 18) 4. A P value of

Results: No patients died of IPN when treated with augmented pancreatic necrosectomy compared to an IPN related mortality rate of approximately 20% in patients treated with traditional active pancreatic necrosectomy (P = 0.22-0.23) 4. No patients required surgical
necrosectomy compared to a subsequent surgical necrosectomy rate of approximately 55% reported in the literature (P = 0.016-0.021).

**Conclusions:** Augmentation with the Argon CleanerXT led to complete recovery and no need for subsequent surgery in all patients. The decreased need for surgery may be related to improved debridement as the Argon CleanerXT is optimized for mechanical fragmentation. Differences in mortality were not found to be statistically significant; however, decreased need for surgical intervention was statistically significant. Given the known positive relationship between surgical intervention and mortality, the lack of statistical significance is likely related to sample size. Larger studies controlling for differences in patient variables are now needed to validate this new treatment modality for IPN.

---

**Abstract No. 556**

**Percutaneous treatment of postoperative biliary leaks refractory to catheter drainage**

J. Core¹, A. Ahmed², B. Toskich³, G. Frey³, J. McKinney³, D. Sella³, R. Paz-Fumagalli³; ¹Mayo Clinic Florida, Jacksonville, FL; ²University of Florida, Gainesville, FL; ³Mayo Clinic, Jacksonville, FL

**Purpose:** Postoperative bile leaks are commonly managed with catheter drainage, but image-guided interventions may be necessary when drainage fails. This retrospective review will present the interventional approaches including three between 2 institutions targeting postoperative biliary leaks refractory to catheter drainage. The interventional approaches included three general categories: cavity ethanol sclerotherapy, selective intra-ductal ethanol sclerotherapy, and ductal occlusion with n-BCA and/or coils. Medical records were reviewed to determine technical success, recurrence rate, and need for reintervention.

**Materials:** A 16-year, retrospective review was performed between 2 institutions targeting postoperative biliary leaks refractory to catheter drainage. The interventional approaches included three general categories: cavity ethanol sclerotherapy, selective intra-ductal ethanol sclerotherapy, and ductal occlusion with n-BCA and/or coils. Medical records were reviewed to determine technical success, recurrence rate, and need for reintervention.

**Results:** This study included 18 patients. 8 leaks were treated with cavity ethanol sclerotherapy, 5 with direct ethanol sclerotherapy of the leaking duct, 2 with combined ethanol sclerotherapy and n-BCA occlusion, 1 with n-BCA and coils, 1 with n-BCA alone, and 1 with coil occlusion of the disrupted duct. 17 of the 18 leaks were cured. One case treated with cavity ethanol sclerotherapy did not resolve after 7 sessions and required operative debridement and coagulation of raw hepatic surface with omentopexy. There were no late recurrences.

**Conclusions:** Postoperative bile leaks that fail catheter drainage can be managed with a combination of cavity ethanol sclerotherapy, ductal ethanol sclerotherapy, and ductal n-BCA and/or coil occlusion with a high rate of technical success and durability.

---

**Abstract No. 557**

**Does donor anatomy impact biliary interventions in living donor liver transplantation?**

A. Smolock¹, P. Abt¹, A. Shaked¹, K. Olthoff¹, S. Trerotola¹, G. Nadolski¹, S. Stavropoulos¹, R. Shlansky-Goldberg¹; ¹University of Pennsylvania, Philadelphia, PA

**Purpose:** Biliary intervention on living donor liver transplants (LDLT) is complicated by variant biliary anatomy found during donor harvest which require multiple anastomoses. This study sought to explore the outcomes of percutaneous biliary drainage (PBD) in this unique population.

**Materials:** An IRB approved retrospective review of 83 patients undergoing LDLT between 2007 and 2017 was performed. Fourteen of 83 LDLT recipients (median age 56 years; 7 males) had post-transplant biliary complications managed with percutaneous biliary drainage (PBD) and stenting in the setting of failed or contraindicated ERCP. Etiologies of liver disease: hepatitis C (n = 6), primary sclerosing cholangitis (n = 2), primary biliary cirrhosis (n = 2), alcoholic cirrhosis (n = 2), biliary atresia (n = 1), and hemochromatosis (n = 1). Median follow-up was 52 months (range, 6-123 months), and median graft survival was 43 months (range, 2-123 months). Donor cholangiograms were reviewed for Huang classification.

**Results:** PBD was performed due to: biliary stricture (9), biliary leak (1), and biliary stricture with leak (4). Median duration of PBD was 8 months (range, 4-27). Ten of 14 (71%) patients were managed with 1 PBD, 3/14 (21%) with 2 PBD, and 1/14 (7%) with 3 PBD. Nine of 14 (64%) patients were successfully managed with PBD and did not require re-operation. Three of 14 (21%) underwent re-transplantation, and two of 14 (14%) had surgical revision. There was one death during follow-up, and PBD management for one patient is ongoing. Thirteen of 14 donors had cholangiograms available for review. Ten of 13 (77%) demonstrated variant anatomy. The most common variant anatomy (7/10, 70%) was a right posterior duct inserting to a left duct (type A3), which comprises 17% of the general population. All patients requiring more than one PBD had donor liver variant biliary anatomy. This corresponded to 40% of patients with donor variant anatomy requiring multiple PBDs.

**Conclusions:** Interventional radiology plays an important, and often salvage, role in the management of biliary complications after LDLT, commonly requiring 2 or more drains. Therefore, knowing the donor biliary anatomy is imperative to treating LDLT patients.

---

**Abstract No. 558**

**TG13 severity classification tool: a better predictor for clinical response after cholecystostomy than CT or ultrasound**

Z. Hu³, Z. Nuffer³, A. Rupasov³, D. Butani²; ¹University of Rochester, Brighton, NY; ²University of Rochester, Rochester, NY

**Purpose:** This is a follow-up to our previously presented work on Tokyo Guideline 2013 (TG13). We compared CT and ultrasound versus the TG13 severity classification tool (SCT) with respect to their ability to accurately predict positive bile culture (PBC) and
likelihood of clinical improvement (CI) after percutaneous cholecystostomy (PC).

**Materials:** With IRB approval, additional reviews of CT and ultrasound of the gallbladder obtained just prior to PC, were performed in the 48 patients with known SCT grading. Imaging outcome was classified as “positive” if the impression made the diagnosis of acute cholecystitis (AC) or if more imaging was recommended to rule out AC. Imaging outcome was classified as “negative” if AC was not suggested and no further imaging was recommended. CI was defined as at least 25% decrease in white blood cell counts 48 hours post procedure. Additionally, 412 ultrasound images were analyzed by a deep convolutional neural network developed with Google Tensorflow (The AI) to extract features suggestive of PBC.

**Results:** Excluding patients classified with severe existing systemic disease or SESD, patients with TG13 grade 2, grade 2 disease without response to conservative therapy for 24 hours (grade 2NR) and grade 3 were more likely to have PBC (p = 0.0107) as well as improved clinical outcome (p = 0.0003). By classifying grade 2, 2NR and 3 as “positive,” TG13 SCT demonstrated 86% sensitivity (SN) and 60% specificity (SP) for PBC as well as 82.7% SN and 87.5% SP for improvement after PC. Analysis of CT or US alone demonstrated lower SN and SP compared to the TG13 SCT (US, 83.3% SN, 31.6 SP for PBC, 70% SN, 12.5% SP for CI. CT, 82.6% SN, 25% SP for PBC, 82% SN, 33% SP for CI). The AI did not find significant difference between US gallbladder images with positive or negative bile.

**Conclusions:** TG13 SCT accurately assessed the likelihood of PBC and successfully predicted clinical improvement. It was superior to imaging in both assessment of PBC and clinical improvement in our cohort. At this time, clinical criteria and their derivatives such as the TG13 SCT, rather than imaging features alone, should guide the decision of PC timing for the IR physician in patients without SESD.

---

**Abstract No. 559**

**In vitro evaluation of non-vascular applications of the ArtVentive EOS occlusive device**

D. Kuetting¹, H. Schild², C. Meyer³, C. Pieper⁴; ¹University of Bonn, Bonn, Germany; ²University Hospital Bonn, Bonn, NRW; ³University of Bonn, Bonn, NRW; ⁴University Hospital Bonn, Bonn, Germany

**Purpose:** The purpose of this in vitro study was to evaluate the occlusive properties of the ArtVentive EOS for transrenal ureteral occlusion and percutaneous occlusion of biliary leaks.

**Materials:** A total of 20 ArtVentive EOS devices were used. Examinations were performed under fluoroscopic guidance. Transrenal ureteral embolization was performed in 10 explanted porcine ureters/kidneys using 8 mm and 11 mm devices (5 devices each). EOS devices were deployed in a mid-ureteral position using a transrenal approach. Intra-pelvic pressure measurements were performed while diluted contrast agent was infused into the renal pelvis until leakage, device dislocation, or pelvic blow out occurred. Biliary leak embolization was performed in 5 explanted porcine livers and in 3 explanted bovine livers. After gaining access to the biliary system via a standard percutaneous transhepatic biliary drainage access artificially created biliary leaks were occluded using either 5 mm or 8 mm EOS devices. Using the 5 mm device peripheral (n = 3), central (n = 1) and cystic duct leaks (n = 1) were occluded. Using the 8 mm device peripheral (n = 1), central (n = 1), main (n = 1) and cystic duct leaks (n = 2) were occluded.

**Results:** Intraureteral device deployment was successful enabling total ureteral occlusion in all cases. Leakage occurred with intra-ureteral pressures between 60-109 cmH2O (8 mm EOS) and 65-125 cmH2O (11 mm EOS). Prior to leakage tubular reflux was seen in all cases, pelvic blowout occurred in half of the studies. Selective deployment and occlusion of central biliary leaks (3/3) and cystic stump leaks (3/3) was successful in all cases. Peripheral leaks could not be selectively catheterized in 3/4 cases making device deployment several millimeters proximal of the leaks necessary.

**Conclusions:** The ArtVentive EOS occlusive device offers an “off the shelf” solution for percutaneous ureteral occlusion. In the biliary system the device allows for single setting occlusion of larger peripheral, central and cystic duct leaks; a disadvantage is that smaller peripheral leaks cannot be treated selectively.

---

**Abstract No. 560**

**Comparing clinical outcomes of percutaneous transperitoneal versus transhepatic cholecystostomy for acute cholecystitis**

J. Kallini¹, D. Patel¹, E. Phillips³, R. Van Allan¹; ¹Cedars-Sinai Medical Center, Los Angeles, CA

**Purpose:** To determine if there is a significant difference in short-term clinical outcomes following percutaneous transperitoneal versus transhepatic cholecystostomy.

**Materials:** 114 patients presented to a single center and underwent percutaneous cholecystostomy from December 2007 to August 2015 utilizing ultrasound ± fluoroscopy. The main indication was acute cholecystitis with high-risk comorbidities precluding surgery. Baseline characteristics and target postprocedural complications of each group were compared using univariate Chi-square analysis.

**Results:** 114 patients (65 male, 49 female) underwent percutaneous cholecystostomy (transperitoneal, n = 59; transhepatic, n = 55). 21 patients required plateau or fresh frozen plasma transfusion prior to the procedure (transperitoneal, 9; transhepatic, n = 12). Complications included bile leak (transperitoneal, n = 4; transhepatic, 1, p = 0.20), hemorrhage (transperitoneal, n = 1; transhepatic, n = 2, p = 0.51), tube dislodgement (transperitoneal, n = 4; transhepatic, n = 1, p = 0.20), and repeat cholecystitis requiring separate admission (transperitoneal, n = 2; transhepatic, n = 2, p = 0.84). No patient experienced gallbladder rupture or duodenal fistula. 18 patients from the transperitoneal cohort underwent postprocedure cholecystectomy: 11 laparoscopic, 3 open, 4 unclear/outside records, mean time from cholecystostomy 30 ± 52 days (due to outlier 211 days later). 18 transhepatic cohort patients underwent postprocedure cholecystectomy: 11 laparoscopic, 6 open, 1 unclear/outside records, mean time from cholecystostomy 109 ± 250 days (due to outlier 1,053 days later). 1 transhepatic and 3 transperitoneal patients died on admission. There were no statistically significant differences in short-term postprocedural complications between the two groups.

**Conclusions:** Transperitoneal and transhepatic percutaneous cholecystostomy techniques have no significant difference in short-term complication rate.
Abstract No. 561

Percutaneous endoluminal brush cytology in patients suspected of malignant biliary obstruction: Experience from a tertiary cancer center in India

S. Kulkarni1, N. Shetty1, S. Patil2, A. Polnaya3, R. Gandhi4, K. Gala2, I. Salroo3, M. Goel5, S. Shrikhande3, M. Ramdawar3, N. Purandare3; 1Tata Memorial Hospital, Mumbai, India; 2Tata Memorial Hospital, Fortis Hospital, Mumbai, India; 3Tata Memorial Hospital, Mumbai, Mumbai, India; 4Tata Memorial Hospital, Mumbai, Mumbai, India; 5Tata Memorial hospital, Mumbai, Mumbai, India

Purpose: To evaluate endoluminal brush cytology during percutaneous biliary drainage in patients suspected of malignant biliary obstruction.

Materials: From January 2010 to December 2016, 106 consecutive patients with obstructive jaundice secondary to suspected malignant biliary obstruction underwent 136 endoluminal brush cytology procedures, during or after percutaneous transhepatic biliary drainage in presence of on-site cytologist. The data was collected retrospectively and analysed. The lesions involved the common bile duct (n=21), common hepatic duct (n=22) and hilum with right or left intrahepatic ducts (n=63). In each patient, up to three (mean-1.3) brush cytology specimens were taken with 8F double lumen brush. Definitive diagnosis in each case was established by the Brush cytology, exploratory laparotomy, biopsy/cytology from any other metastatic site or combination of tumour markers, radiological or clinical suspicion and increase in size or cytology from any other metastatic site or combination of tumour markers.

Results: 66 out of 106 patients had correct diagnoses of malignancy on brush cytology. 3 diagnoses proved to be true-negative & 37 were false-negative. 9 out of 22 patients (40.1%) had malignancy diagnosed in 2nd attempt and 1 of 3 patients (33.3%) had malignancy diagnosed with 3rd attempt. Diagnostic sensitivity and specificity brush cytology for malignant nature of biliary strictures was 64.1% and 100% respectively with accuracy of 65.1%. The sensitivity of brush cytology was highest in proximal hilar block 67.8% as against 38.5% noted for lower CBD block, this difference was statistically significant (p-value ≤0.05). Anatomostic site recurrence had a sensitivity of 46.1% in diagnosing malignant nature of disease. No complications were related to the procedure.

Conclusions: Percutaneous endoluminal brush cytology is a relatively accurate procedure that is safe & easy to perform through a transhepatic biliary drainage tract. Sensitivity to diagnose malignant stricture was higher in primary and proximal hilar block as against lower CBD block & anastomotic site strictures.

Abstract No. 562

Paclitaxel drug-coated balloon cholangioplasty in the treatment of biliary-enteric anastomotic stricture

V. Young1, R. Lewandowski1, B. Thornburg1, A. Riaz1, S. Mouli1, R. Salem1, K. Desai1; 1Northwestern University, Chicago, IL

Purpose: Treatment of biliary-enteric (B-E) anastomotic stricture is difficult, often requiring protracted management via several procedures. Stricture restenosis is a common issue; paclitaxel drug coated balloons (DCB) have been shown to reduce restenosis via an antiproliferative mechanism in peripheral arterial disease applications; use of these devices may reduce lesion restenosis in anastomotic strictures. In this study, we seek to evaluate the efficacy of DCB treatment of B-E anastomotic strictures.

Materials: Patients who underwent treatment of B-E anastomotic strictures with DCB from 9/2016 to present were reviewed. Patients received initial percutaneous drain placement; approximately 1 week later standard/cutting balloon angioplasty and 7 mm DCB application for 3 minutes at nominal inflation was performed. Symptom improvement was qualitatively assessed. Alkaline phosphatase (AP) and total bilirubin (TBili) values were collected prior to initial biliary intervention and following DCB cholangioplasty. Paired t-test was performed; significance was determined at p <0.05.

Results: Six patients (5M:1F, mean age 70) with B-E anastomotic strictures treated with DCB were identified; technical success was achieved in 5; these patients experienced symptomatic improvement. One patient had B-E stricture at a transplant hepaticojejunostomy. Four patients were found to have benign strictures, one patient had a malignant stricture and represents the only treatment failure. Prior to internal/external drain placement and DCB cholangioplasty, the average TBili was 3.8 ± 1.9 (mean ± SEM), which trended downward to 1.4 ± 0.6 (mean ± SEM) following DCB therapy (p = 0.08). Prior to internal/external drain placement and DCB cholangioplasty, the average AP was 439 ± 136 which decreased to 262 ± 77 (p = 0.03). No complications were encountered in this series.

Conclusions: DCB cholangioplasty demonstrates early promise in the treatment of benign biliary-enteric anastomotic stricture. Further study needs to be performed to validate these findings and precisely define patients that could benefit from this intervention.

Abstract No. 563

The utility of mixture of “lipiodol-indigo carminoideraine gel” for preoperative pulmonary nodule localization

T. Hasegawa1, H. Kuroda3, Y. Sato3, Y. Inaba3, H. Yamaura7, S. Murata1, M. Kato1, Y. Onoda1, Y. Sakao1; 1Aichi Cancer Center Hospital, Nagaya, Aichi

Purpose: To evaluate the safety and efficacy of preoperative marking using a mixture of lipiodol, indigo carmine, and lidocaine gel (LIL) for thoracoscopic pulmonary nodule resection.

Materials: A total of 168 sessions of marking was performed before thoracoscopic surgery for 157 patients (83 men and 74 women; median age, 66years; range, 29-84years) with 184 nodules (mean size, 1.2 ± 0.6 cm; range, 0.3-3.6 cm). Twenty-eight patients (17.8%) had emphysema. Sixty-seven nodules (36.4%) were predominantly ground glass opacity on CT image. The mean distance between lung surface and the nodule were 0.8 ± 0.7 cm (range, 0.3-9 cm). LIL was injected near the nodule using 23-gauge needle under CT fluoroscopic guidance. Puncture was performed 1 to 3 times (mean, 1.2 ± 0.4) in a session for the mean number of target nodules of 1.1 ± 0.3 (range, 1.3). Technical success, safety, necessity of intraoperative fluoroscopy, and clinical success were
Optimal pleural fluid volume for diagnosing malignancy: the more the better?

I. Momah Ukeh1, S. Chowdhury2, A. Kim1, J. Cardella1, D. Buckley1, D. Field3, G. Lynskey1, E. Cohen1, T. Caridi1; 1Medstar Georgetown University Hospital, Washington, DC; 2Georgetown University School of Medicine, Washington, DC

Purpose: The purpose is to determine the optimal pleural fluid volume needed to diagnose malignancy using pleural fluid cytology. Median survival rates after malignant pleural effusion (MPE) diagnosis are approximately 4-6 months, highlighting the importance of early diagnosis to guide therapy. Past studies suggest a wide range of volumes, from 10-300mL, as sufficient to make a diagnosis. However, the sensitivity for MPE diagnosis are low. Pleural fluid cells are heterogeneously distributed within the pleural cavity and larger volume samples may be more likely to recover malignant cells. There is no literature comparing the diagnostic yield of high volume pleural fluid samples (>1000mL) to low volume samples.

Materials: Retrospective analysis of 233 thoracenteses from 2013 to 2017 was performed. Inclusion criteria were cases with known or suspected MPE with fluid sent for cytologic analysis by combined direct smear/cytospin and cell block preparations. Demographic, clinical, and procedural data were obtained from review of the medical records. Fluid samples were defined as large volume if greater than 1000mL and low volume if between 1mL and 1000mL. Statistical significance of outcomes between these volumes was measured using Pearson’s chi-squared test.

Results: 109 thoracenteses samples from 96 (42 female and 54 male) patients were sent for cytologic analysis in cases of known or suspected malignancy. 26 cases (24%) were positive for malignancy. Average volume for large volume samples was 1200mL ± 245 (range, 1000 to 1750mL) and for low volume samples was 63mL ± 135 (range, 2 to 800mL). 64% of large volume samples were positive for malignancy compared to 19% positivity in low volume samples. The rate of cytological detection of malignancy was significantly higher with large volume thoracentesis (p = 0.001).

Conclusions: Large volume thoracentesis analysis allows for a significant improvement in cytological detection of malignancy when compared to low volume samples. Often, in practice a small sample is obtained for analysis and the remaining extracted fluid is discarded. This study emphasizes the need to implement analysis of larger volume samples (>1000mL) to improve the diagnostic yield for MPE.

Abstract No. 565

An efficient and precise technique of preoperative pulmonary nodule localization: computer tomography-guided patent blue dye injection

K. Ko1, H. Hsu2, T. Huang3, S. Lee3, C. Chang4, H. Chang5, H. Gao4; 1Department of Radiology, Tri-Service General Hospital and National Defense Medical Center, Taipei, Nei-Hu, Taiwan; 2Department of Radiology, Tri-Service General Hospital and National Defense Medical Center, Taipei, Nei-Hu; 3Division of Thoracic Surgery, DepartTri-Service General Hospital and National Defense Medical Center, Taipei, Nei-Hu; 4Department of pathology, Tri-Service General Hospital and National Defense Medical Center, Taipei, Nei-Hu

Purpose: Resection of small pulmonary nodules via video assisted thoracic surgery (VATS) is usually challenging without preoperative localization. The aim of this study is to evaluate the efficacy of our experience in CT-guided preoperative localization with patent blue dye injection to facilitate thoracoscopic resection of pulmonary nodules.

Materials: 125 consecutive patients underwent CT-guided localization with injection of patent blue dye between June 2015 to June 2016. The clinical and radiological characteristics, technical details, pathological results and procedure related complications were retrospectively reviewed.

Results: 125 consecutive patients (44 men and 81 women) with 137 indeterminate pulmonary nodules (46 pure ground-glass opacity nodules, 41 part-solid nodules and 50 solid nodules) were included in the study. The mean size of the nodules was 9.5 mm (3.0–22.0 mm). The mean distance between the nodule and pleural surface was 12.1 mm (2.0–42.1 mm). The mean procedure time of CT-guided localization was 16.5 min (10–50 min). The mean time interval from dye injection to operation was 188 min (range, 24–1440 min). Pneumothorax developed in forty patients (32%) and focal parenchymal hemorrhage was identified in 16 patients (12.8%) after localization. No patient required air drainage. Although non-visualization of dye marking occurred in 2 patients, focal hematoma and puncture hole can be identified on the pleural surface. Therefore, all nodules were successfully resected by VATS without conversion to open thoracotomy. 103 nodules (75.1%) were confirmed as malignancies including 87 primary lung cancer.

Conclusions: CT-guided patent blue dye localization is an efficient technique which facilitates successful resection of small pulmonary nodules even if a long duration from localization to operation is needed.
Abstract No. 566

Safety and feasibility of ultrasound-guided gastric access for percutaneous transabdominal gastrostomy tube placement

P. Shukla1, M. Kolber2, R. Tapnio2, A. Zybulewski2, R. Patel2; 1Mount Sinai Hospital, The Icahn School of Medicine, New York, NY; 2Mount Sinai Beth Israel, New York, NY

Purpose: To evaluate the safety and feasibility of ultrasound guidance gastric access for percutaneous retrograde transabdominal gastrostomy (G) tube placement.

Materials: Twenty-eight patients undergoing percutaneous retrograde transabdominal G tube placements utilizing ultrasound-guided gastric access at our institution from April 2015 to November 2017 were retrospectively identified. Technical success was defined as successful placement of a percutaneous “push-type” G tube with ultrasound-guided access. Chart review provided demographic data, clinical indication, procedural information (gastrostomy tube size fluoroscopy times, radiation dose), complications, dislodgements/ replacements and follow-up.

Results: Twenty-eight patients (15 male, 13 female; average age: 60.7 ± 15.4 years) undergoing 31 sonographic access transabdominal G tube placements were identified. All patients had successful placement of G tubes with ultrasound-guided gastric access. Two patients had subsequent G tube placements after the primary tube was removed secondary to resuming per oral intake for nutrition. There were no procedure-related complications. Three tubes became inadvertently dislodged requiring replacement. One access site infection was treated conservatively with antibiotics. Average fluoroscopy time was 2.7 ± 1.4 minutes and average radiation dose was 220 ± 202 μGy².

Conclusions: Ultrasound-guided access for gastrostomy placement is safe and feasible and can be performed with small fluoroscopy times resulting in decreased low and operator radiation dose.

Abstract No. 567

Transnasal and transgastric snare technique for the placement of retrograde primary jejunostomy tubes

R. Srinivasa1, J. Chick2, A. Hage1, J. Shields1, K. Cooper1, W. Saad1, B. Majdalany1; 1University of Michigan Medical Center, Ann Arbor, MI; 2University of Michigan Health System, Ann Arbor, MI

Purpose: To report technical success and clinical outcomes of the transnasal and transgastric snare techniques for placement of retrograde primary jejunostomy tubes.

Materials: 6 female patients underwent the retrograde snare technique for the placement of a primary jejunostomy tube. Mean age was 54.5 years (range, 25-82 years). Patients presented with Roux-en-Y gastric bypass (n = 2), sleeve gastrectomy (n = 1), esophagectomy (n = 1), intra-thoracic stomach (n = 1), and gastroparesis (n = 1). Patients had targeting devices placed via either a transnasal (n = 5) or transgastric (n = 1) approach. Loop snare devices were used as a target in 5 patients and an uncovered stent in 1. Ultrasound and fluoroscopy were used to confirm the targeting device was within a superficial bowel loop in 4 patients, and cone-beam CT and fluoroscopy alone in 1 patient each. All snares and the stent were punctured with a styleted needle and used to capture a wire thereby obtaining through-and-through access for subsequent tract dilatation and placement of a primary retrograde jejunostomy.

Results: All (n = 6) transnasal and transgastric snare technique retrograde primary jejunostomy tube placements were technically successful. All tubes were 16 French MIC jejunostomy tubes (Halyard Health; Alpharetta, Georgia). 1 patient had abdominal pain on postoperative day 1 and couldn’t begin feeds until postoperative day 3. 1 patient’s tube was too long and extended above the gastroesophageal junction resulting in aspiration, requiring repositioning 4 days later. The remaining 4 patients were able to begin tube feeds on postoperative day 1. 1 patient’s tube hub cracked 6 weeks after placement and required exchange. Twenty-eight patients undergoing percutaneous retrograde transabdominal gastrostomy (G) tube placements were identified. All patients had successful placement of a percutaneous “push-type” G tube with ultrasound-guided access. Chart review provided demographic data, clinical indication, procedural information (gastrostomy tube size fluoroscopy times, radiation dose), complications, dislodgements/ replacements and follow-up.

Conclusions: The transnasal and transgastric snare technique is a feasible and simple technique for the placement of retrograde primary jejunostomy.

Abstract No. 568

Percutaneous gastrostomy for treating dilatation of the excluded stomach after Roux-en-Y gastric bypass surgery

S. Majumdar1, O. Akinwande2, R. Ramaswamy2; 1Washington University in St. Louis, St. Louis, MO; 2Mallinckrodt Institute of Radiology, St. Louis, MO

Purpose: To describe the use of percutaneous gastrostomy for decompression of the excluded stomach in patients with roux-en-Y gastric bypass (RYGB) and assess feasibility and safety of this approach.

Materials: Between Jan 2001-Aug 2017, 10 consecutive RYGB patients who underwent decompressive gastrostomy of the excluded stomach were identified in an institutional database. Technical success was defined as successful gastrostomy tube placement in the bypassed stomach using fluoroscopy or ultrasound guidance. Clinical success was established if dilatation of the excluded stomach improved after gastrostomy with resolution of associated symptoms. Charts were interrogated for treatment-related adverse events postprocedure.

Results: The cohort was predominantly female (9/10), with an average age of 54 ± 14 years. Median follow-up was 35.2 months (range, 0.6-115). Indications for decompressive gastrostomy included small bowel obstruction (6/10) or obstruction of the afferent limb at the jejunojejunostomy anastomosis (4/10). The most common presenting symptoms were abdominal pain, distension, and vomiting. All patients had successful gastrostomy placement in the excluded remnant using only ultrasound and fluoroscopy guidance, with no procedural complications. In 2 patients, a 12 Fr locking pigtail catheter was used. In 7 cases, a 14 Fr pigtail catheter was used; one of these tubes was later upsized to 18 Fr. In one case,
Interventional urethral realignment as a radical treatment in posterior urethral disruption accompanied by complex pelvic fracture

C. Jeon, C. Kim, H. Kwon; Pusan National University Hospital, Busan, Republic of Korea

Purpose: Unlike anterior urethral injury, posterior urethral rupture accompanied by complex pelvic fracture would have the distance between the ruptured urethra becoming wider due to pelvic hematoma, and thus, interventional urethral realignment would be expected to face similar difficulties as surgical urethral realignment. The purpose of this study was to evaluate the clinical efficacy of interventional urethral realignment as a radical treatment in patients with posterior urethral disruption.

Materials: This retrospective study included 8 patients with traumatic posterior urethral disruptions who were treated with interventional urethral realignment between November 2016 and September 2017. All 8 patients were men with the mean age of 50.5 years. Reviewed results included patient demographics, technical success rate of interventional urethral realignment, fluoroscopic findings, manner of procedure, required procedure time, duration of urethral catheterization, and procedure-related complications.

Results: Interventional urethral realignment was technically successful in 6 of 8 patients (75.0%). The majority of patients were young male involved in motor vehicle crashes. In 5 patients, the catheter previously placed by retrograde urethrography was used as a landmark, and the antegrade guidewire was successfully navigated through the free space of urethra separated further by rupturing and exited through the outer urethral orifice by finding the true lumen of the distal urethra. In one patient, the rendezvous technique with a snare catheter in the free space was used. The mean procedure time was 51.2 minutes (range, 40–65 min). The mean duration of urethral catheterization after interventional urethral realignment was 63 days (range, 48–94 d). There were no immediate complications related to procedure, although all patients developed symptomatic urethral stenosis after urethral realignment.

Conclusions: Interventional urethral realignment is a safe and minimally invasive procedure that can be performed in a patient with posterior urethral rupture accompanied by complex pelvic fracture. Thus, it can be viewed as a radical treatment that can reduce the frequency of invasive surgical procedures.
4Asan Medical Center, Seoul-City, Republic of Korea; 5Asan Medical Center, Seoul-City, Republic of Korea; 6Asan Medical Center, University of Ulsan College of Medicine, Seoul, Republic of Korea

Purpose: The purpose of this study was to evaluate an EW-7197–eluting nanofiber-covered stent (NFCS) for granulation tissue formation after stent placement in a canine urethral model.

Materials: All experiments were approved by the committee of animal research. A total of 12 NFCSs were placed in the proximal and distal urethras of six dogs. Dogs were divided into two groups with 3 dogs each. The control stent (CS) group received NFCs and the drug stent (DS) group received EW-7197 (1000 μg)-eluting NFCs. All dogs were sacrificed 8 weeks after stent placement. Histologic findings of the stented urethra were compared using the Mann-Whitney U test.

Results: Stent placement was technically successful in all dogs without procedure-related complications. On urethrographic analysis, the mean luminal diameter was significantly larger in the DS group than in the CS group at 4 and 8 weeks after stent placement (all p < 0.05). The in vitro release study demonstrated that approximately 80% of the drug was eluted from the stents within 1 day (all p < 0.05). The in vitro release study demonstrated that approximately 80% of the drug was eluted from the stents within 1 day (all p < 0.05).

Conclusions: The EW-7197–eluting NFCS is effective and safe for suppressing granulation tissue formation after stent placement in a canine urethral model.

Abstract No. 572

Renal access for repeat percutaneous nephrolithotomy in patients with recurrent kidney stones: feasibility, safety and endourologic procedure outcomes

M. Chappell1, K. Kobayashi1, K. Durwas1, D. Zhang1, O. Shapiro1, M. Karmel2; 1SUNY Upstate Medical University, Syracuse, NY; 2Upstate Medical University, Syracuse, NY

Purpose: We evaluated the feasibility and safety of renal access, and surgical outcomes in patients with recurrent kidney stones who underwent repeat percutaneous nephrolithotomy (PCNL) and compared those in PCNL-naïve patients.

Materials: Between April 2012 and December 2016, 158 kidneys in 150 patients (73 male, median age: 55 years) were percutaneously accessed for PCNL. Of these, 24 kidneys (11.3%) in 21 patients were accessed for repeat PCNL for recurrent kidney stones (Repeat group). The rest of the 134 kidneys in 129 patients were PCNL-naïve (Naïve group). A stone-bearing calyx was generally accessed at the urologist's request. Among the repeat group, 18 kidneys (75.0%) were accessed through a previously accessed calixes. Technical success rates of renal access (overall and through a stone-bearing calyx), fluoroscopy time (minutes), and incidence of complications related to renal access which resulted in cancellation of same-day PCNL were compared between groups. Stone clearance (no residual stones > 5 mm on post-PCNL imaging) and incidence of complications related to PCNL were also compared.

Results: The overall technical success rate of renal access between groups were not significantly different (95.8% (23/24) vs (97.7% (131/134), P = 0.29). However, renal access through a stone-bearing calyx was significantly less achieved in the repeat group than the naïve group (82.6% (19/23) vs 94.9% (112/118), P = 0.05). No statistical difference in mean fluoroscopy time (10.4 vs 10.6, P = 0.49) and incidence of access-related complications (9.5% vs 5.4%, P = 0.52) were seen between groups. The complications included infection (2/24 vs 6/134, P = 0.35), bleeding (3/134, P = 0.61) and others (n = 2 in the PCNL naïve group). No statistical difference in stone clearance rate (63% vs 60%, P = 0.78) and incidence of PCNL-related complications (19.0% vs 24.8%, P = 0.72) were seen between groups.

Conclusions: Renal access for repeat PCNL was feasible without significant difference in incidence of complications or fluoroscopy time compared to that for first-time PCNL. Access through a previously accessed stone-bearing calyx was also feasible, but carried a higher technical failure rate than that of PCNL naïve.

Abstract No. 573

Outcomes of ureteroplasty and stenting of anastomotic ureteral strictures occurring after urinary diversion and renal transplantation

B. Shin1, S. Reddy2, S. Trerotola3, P. Ramchandani4; 1University of Pennsylvania, Philadelphia, PA; 2Main Line Health System, Bala Cynwyd, PA; 3University of Pennsylvania Medical Center, Philadelphia, PA; 4University of PA Medical Center, Philadelphia, PA

Purpose: To report outcomes of percutaneous ureteroplasty and stenting of anastomotic ureteral strictures which occurred within 1 year of urinary diversion (ureteroenteric anastomosis -UEA) or renal transplantation (ureterovesical anastomosis-UVA).

Materials: We retrospectively identified patients who underwent ureteroplasty with percutaneous nephroureteral (PCNU) or double pigtail ureteral stent placement (stent) for benign anastomotic strictures occurring within one year of urinary diversion or renal transplantation from March 2004 to July 2016 (N = 54). 31 patients had UEA strictures (25 men and 6 women; mean age 65, 19 ileal conduits and 12 continent divergences) and 23 renal transplant patients had UVA strictures (15 men and 8 women; mean age 53). Mean follow-up was 31 months (range, 1.107 months). Primary endpoint was freedom from ureteral stent or nephrostomy without the need for surgical revision (i.e., tube free).

Results: Mean balloon diameter used for ureteroplasty in the urinary diversion and renal transplant cohorts was 7.7 mm and 6 mm, respectively (p < 0.01). Mean French size of PCNU or stent placed after ureteroplasty was 10 French. In the UEA group, 8/31 (25%) patients underwent surgical revision and 18/31 (58%) required chronic ureteral stents after failed ureteroplasty. Only 5/31(16%) were tube free without surgery. In the UVA cohort, 2/23 (8%) patients underwent surgical revision and 9/23 (39%) required chronic indwelling ureteral stents after failed ureteroplasty. 12/23 (52%) renal transplant patients were tube free without surgery. By Kaplan Meier analysis, the actuarial mean time to PCNU or stent removal was 81 ± 10 months and 41 ± 11 months for UEA and UVA respectively (p = 0.01).

Conclusions: Ureteroplasty had greater success in achieving the primary endpoint of freedom from PCNU or ureteral stent in patients after renal transplantation as compared with patients after urinary diversion.
Abstract No. 574

Ability to aspirate retained contrast from bladder via nephroureterostomy tube (NUT) is a predictor of successful capping trial
W. Shay1, D. Fleischer1, M. Maybody1; 1Memorial Sloan Kettering Cancer Center, New York, NY

Purpose: To assess outcomes of capping trials among patients with complete aspiration of retained contrast from bladder via NUT.

Materials: Our Institutional Review Board approved retrospective review of all NUT placement, NUT exchange and conversion of nephrostomy catheter into NUT performed during June 2013 to June 2015 (n = 578). Cases were excluded due to lack of imaging of bladder (n = 37), incomplete aspiration of bladder (n = 324), no attempt at capping NUT (n = 166), others, including non-compliant bladder, bladder outlet obstruction and catheter malposition (n = 14). Study group consisted of 37 procedures in 34 patients (male 19, female 15, age 2-83 years, average 58, median 61) mostly with cancer (prostate 8, endometrial 5, bladder 4, colorectal 4, breast 2, gastric 2, neuroblastoma 2, cervical 1, ovarian 1, renal 1, sarcoma 1, urethelial 1 and testicular 1) and one with Crohn’s. Medical records were reviewed to assess outcomes of capping trial. Exact 95% confidence intervals (95%CI) were calculated.

Results: Among patients with complete aspiration of retained contrast, 30 (81%, 95%CI: 65%-92%) catheters were successfully capped (range, 12-94 days, average 40, median 24.5) until planned conversion to internal stent (23), routine exchange (5), removal (1) or death unrelated to catheter (1). Substantially fewer procedures were unsuccessful; 7 (19%, 95%CI: 8%-35%) capping trials were unsuccessful (range, 2-22 days, average 12, median 10) due to leakage (3), elevated creatinine (2), fever/hematuria (1) and nausea/vomiting (1).

Conclusions: There is high likelihood of capping trial success among patients with complete aspiration of retained contrast from bladder via NUT.

Abstract No. 575

A retrospective analysis of a single-center experience with percutaneous nephrostomy during pregnancy
Y. Epelboym1, K. Desai1, Z. Yan1, S. O’Horo1; 1Brigham and Women’s Hospital, Boston, MA

Purpose: Percutaneous nephrostomy has been used to treat symptomatic renal obstruction. Although there have been small published series describing safety and efficacy, this study assesses our experience over 12 years placing PCNs in pregnant women in a tertiary care academic medical center.

Materials: In this IRB approved study, all patients undergoing percutaneous nephrostomy (PCN) from 7/1/2005 through 7/1/2017 were identified through a Hi-IQ database search. Only patients who were pregnant at the time of PCN placement were included. A retrospective review was performed to include demographics, gestational age, clinical indications, technical success, maternal outcome, fetal outcome, and complications.

Results: Twenty-one subjects were included with a median age of 28 (range, 19-38). The median gestational age at the time of intervention was 26 weeks (range, 8-38). Of the 21 patients undergoing percutaneous nephrostomy 7 (33%) had hydronephrosis secondary to calculi, 7 (33%) due to congenital ureteral dysfunction and childhood ureteral re-implantation, 2 (10%) had failed internal ureteral stenting, 2 (10%) had urosepsis. There was one case each of the following: gravid uterus with ureteral compression, ureteral trauma in the setting of surgery for presumed ovarian torsion, and hydronephrosis with associated flank pain. Eleven (52%) patients had moderate hydronephrosis, 8 (38%) had severe hydronephrosis, and 2 (10%) had mild hydronephrosis. Technical success was 100% (21/21). 91.5% of pregnancies continued to term. One fetus in the cohort was delivered prematurely at 31 weeks (4.7% preterm delivery). One pregnancy was terminated as it was undesired. There were no major or minor complications related to the procedure.

Conclusions: Percutaneous nephrostomy during pregnancy has excellent technical success and good maternal and fetal outcomes.

Abstract No. 576

Orthotopic ovarian cancer: molecular imaging-monitored radiofrequency hyperthermia-enhanced intratumoral herpes simplex virus-thymidine kinase (HSV-TK) gene therapy
Y. Li1, X. Yang2, F. Zhang3, S. Zhao3, G. Jin4, L. Zhao5, P. Li6, Y. Zhou6; 1Guizhou Provincial People’s Hospital, Guiyang, Guizhou; 2N/A, Mercer Island, WA; 3University of Washington School of Medicine, Seattle, WA; 4Renji hospital, School of Medicine, Shanghai Jiaotong University, Shanghai, Shanghai; 5University of Washington, Seattle, WA; 6Image-Guided Biological Molecular Interventions Research and Division of Interventional Radiology, Seattle, WA

Purpose: To validate the feasibility of using imaging-guided RF hyperthermia to enhance intratumoral HSV-TK/Ganciclovir (GCV) suicide gene therapy of ovarian cancers, monitored by optical and ultrasound imaging.

Materials: Human ovarian cancer cells (SK-OV-3) labeled with luciferase/lentivirus for in vitro confirmation and rats with the same luciferase-positive orthotopic ovarian cancers for in vivo validation were divided into four groups with different treatments: i) combination treatment with intratumoral HSV-TK/GCV-mediated gene therapy plus RFH; ii) gene therapy alone; iii) RFH alone; iv) phosphate buffered saline (PBS). MTS assay and confocal microscopy were used to evaluate the cell viability. Bioluminescence optical and ultrasound imagings were used to monitor the changes of tumor size and bioluminescence signal intensities at different time points (days 0, 7 and 14 posttreatment). The imaging findings were correlated with subsequent pathology confirmation.

Results: MTS assay demonstrated the lowest cell proliferation in the group with combination therapy, compared with the other three control treatments (41.0 ± 6.1% vs 47.8 ± 1.5% vs 97.3 ± 8.5% vs 100%, p<0.01), as corresponded to the smallest number of survived cells by confocal microscopy and the lowest bioluminescence signal by optical imaging. Ultrasound imaging showed the smallest tumor volume with combination therapy, compared with the other three control treatments (0.23 ± 0.19 vs 1.26 ± 0.21 vs 5.43 ± 0.33 vs 6.74 ± 0.36, p<0.05). Bioluminescent optical imaging demonstrated a significantly decreased bioluminescence signal intensity in combination
therapy, compared with the other three treatments (0.35 ± 0.12 vs 1.26 ± 0.10 vs 3.43 ± 0.27 vs 3.90 ± 0.12, p<0.05). Both imaging findings were confirmed by pathology, demonstrated as the significantly increased apoptotic cells in the combination therapy group.

Conclusions: We have successfully established the “proof-of-principle” of using image-guided intratumoral RFH to enhance HSV-TK-GCV gene therapy of rat ovarian cancers, which may provide a new opportunity for effectively managing ovarian cancers by simultaneous integration of radiofrequency technology, interventional oncology, and direct gene therapy.

Abstract No. 577

Percutaneous CT-guided cryoablation of the posterior vagal trunk for management of mild to moderate obesity: a pilot trial
J. Prologo1, A. Mittal2, J. Knight3, S. Horesh Bergquist2, H. Matta4, D. Corn5; 1Emory University School of Medicine, Division of Interventional Radiology and Image Guided Medicine, Atlanta, GA; 2Emory University School of Medicine, Atlanta, GA; 3Emory Healthcare, Roswell, GA; 4Emory University Hospital, Atlanta, GA; 5Case Western Reserve School of Medicine, Cleveland, OH

Purpose: The purpose of this pilot trial is to evaluate the feasibility of percutaneous CT-guided cryoablation of the posterior vagal trunk for future use in a larger scale study of its role in the management of mild-moderate obesity.

Materials: Ten subjects (8 female, 2 male, mean age 44 ± 12 years [range 27-66]) with BMI > 30 underwent percutaneous CT-guided cryoablation of the posterior vagal trunk along the distal esophagus. Following an initial consultation and the procedure, each subject received a 24-hour phone call and was followed up in clinic on day 7, 45, and 90 post procedure. Subjects were primarily evaluated for identification of procedure related complications or adverse events. Anthropometric measurements were obtained at baseline and each follow-up visit. In addition, each subject was administered Food Frequency and Quality of Life Questionnaires, as well as a Patient Global Impression of Change Tool for evaluation of appetite.

Results: At present, we have followed these patients for an overall average of 41 days. By the late breaking deadline, all of them will have completed the 90-day follow-up. So far, 100% of the patients are reporting much less appetite following the procedure, and the overall average weight loss is 4% body weight. There have been no procedure-related complications or adverse events.

Conclusions: Percutaneous CT-guided cryoablation of the posterior vagal trunk is feasible, and may represent a safe, efficacious way to manage mild to moderate obesity.

Abstract No. 578

Percutaneous, image-guided intramuscular botulism toxin type A (BTA) injection to facilitate abdominal wall reconstruction (AWR) in patients with recurrent, large-defect hernias

Purpose: Incisional ventral hernias occur in about 20% of patients after laparotomy. Despite advances in surgical technique, hernia recurrence occurs in up to 73% of patients with large ventral hernias and “loss of domain” in which more viscera reside outside the abdominal cavity than inside. Hernia recurrence and complication rate can be significantly reduced if the midline is closed over mesh without having to bridge a fascial gap. Preoperative percutaneous BTA injection into the oblique muscles can facilitate AWR by allowing stretching of the abdominal wall to facilitate fascial reapproximation. This study reports a single-center experience in the technique and efficacy of percutaneous BTA injection to facilitate AWR of recurrent, large-defect ventral hernias.

Materials: From 2013-17, patients with recurrent large-defect hernias referred for percutaneous BTA injection were recorded in a HIPAA-compliant database. Under US or CT guidance, the external and internal oblique muscles at up to three sites were targeted with 16 units BTA per site at the anterior axillary line. Transversalis muscles were only injected if appropriately thickened. Peri-operative findings and postoperative outcomes were recorded.

Results: 20 patients underwent percutaneous BTA injection and had ≥ 3 months follow-up. A range of 42 to 300 units BTA were used (average dose: 182.8 units). Average ventral hernia defect size was very large: 22.9 × 17.5cm. 18 patients were injected bilaterally and 2 unilaterally. There were no immediate or delayed injection-related complications. Average time to surgical AWR after injection was 34.6 days (range, 7-72 days). Average follow-up was 13.1 months (range, 3 mos-52 months). Successful fascial closure of the defect was possible in 19 out of 20 patients with partial/near complete closure in 1. There was no recurrence of hernias in any patients.

Conclusions: This study demonstrates that preoperative intramuscular BTA injection facilitates AWR with higher clinical success than compared to historical controls. Intramuscular BTA injection may prove a significantly beneficial preoperative adjunct for selected patients, though larger, comparative studies are warranted.

Abstract No. 579

Percutaneous CT-guided cryoablation for the management of pudendal neuralgia: long-term outcomes
J. Prologo1, A. Mittal2, J. Knight3, D. Hsu4, R. Dolan4, D. Corn5; 1Emory University School of Medicine, Division of Interventional Radiology and Image Guided Medicine, Atlanta, GA; 2Meharry Medical School, Nashville, TN; 3Emory Healthcare, Roswell, GA; 4Emory University School of Medicine, Atlanta, GA; 5University of Buffalo, Buffalo, NY

Purpose: To analyze the long-term safety and efficiency of CT-guided percutaneous cryoablation of the pudendal nerve.

Materials: Patients who underwent CT-guided pudendal nerve cryoablation for the treatment of pudendal neuralgia were identified...
from an existing database. Patients were contacted via email, directed to an online survey, then contacted again via follow-up telephone call for purposes of answering questions or providing survey clarification. 51 patients (42 females, 9 males, mean age 58.1 ± 12.7 [range, 28-76] years) completed a 22-question standardized survey comprised of consensus recommended outcome instruments for patients who undergo an intervention in the setting of chronic pain. The results were correlated with baseline values and characteristics from the medical record. The electronic medical record was further scrutinized for evaluation of procedural technical success and/or procedure related complications, as defined by the SIR. Analyses of changes in baseline pain intensity and multiple variable correlation were performed. Patients were classified as “responders” or “non-responders” for purposes of data analysis and stratification based on the Patient Global Impression of Change (PGIC) Scale and a specific survey question asking whether participants would undergo the original procedure again, if given the chance.

Results: The mean time to follow-up post procedure was 1.5 ± 0.9 years (range, 63 days-3.6 years). The mean duration of patient symptoms prior to cryoablation was 8.4 years ± 7 years (range, 60 days-32 years). The overall mean change in baseline pain intensity for the entire group per Visual Analog Scale was -2.5 cm [-3.2, -1.7], and the mean change in baseline pain intensity for the responder group (63%) was -3.3 cm [-4.1, -2.5], both of which were statistically significant (p<0.0001). There were no procedure related complications. The incidence of potentially unwanted symptoms following pudendal nerve destruction was 12% (sexual), 10% (urinary), and 1% (fecal).

Conclusions: Percutaneous CT-guided cryoablation of the pudendal nerve is safe and efficacious but is associated with potentially unwanted sequelae that should influence patient selection.

Abstract No. 580

Initial experience of CT-guided pulsed radiofrequency ablation of the pudendal nerve for chronic recalcitrant pelvic pain

M. Collard1, X. Yin2, A. Patel2, K. Scott3, A. Chhabra1; 1UT Southwestern Medical Center, Dallas, TX; 2University of Texas Southwestern, Dallas, TX; 3UT Southwestern, Dallas, TX

Purpose: Chronic recalcitrant pelvic pain is a complex, multifactorial disorder for which directed neuropathic therapies can often provide some degree of relief. Radiofrequency ablation (RFA) of peripheral nerves has been demonstrated to provide neuropathic pain relief, with little data on pelvic nerve RFA or the use of CT guidance.

Materials: Single academic center IRB-approved retrospective cross-sectional study utilizing chart review and follow-up phone calls. All patients who underwent CT-guided pudendal nerve RFA with concomitant perineural injection (PNI) during a 3-month period were included. All patients had at least one prior PNI with positive block and no prior ablation. Pulsed RFA with a 22-gauge probe using the Neurotherm NT2000iX™ (St. Jude Medical) was performed on 14 pudendal nerves in 10 patients (male:female = 3:7) with age 60 ± 14 years (mean ± SD) and BMI 24.6 ± 3. Duration (in weeks) and degree of pain relief (0-10 on VAS scale) from RFA and prior PNI were compared. Subjective change in quality of life and pain medication requirement were recorded.

Results: All 14 ablations demonstrated technical success without immediate complication. No long-term complications (up to 9 months follow-up) were identified, although one patient developed interstitial cystitis, possibly related to intraprocedural perineural contrast injection used to confirm needle position. Best reported pain scores following RFA averaged 2.1 ± 2.3, compared to 3.1 ± 2.8 and 2.4 ± 2.6 following the first and last PNI, respectively (Wilcoxon signed rank test: p = 0.11, 0.75). Duration of relief following RFA averaged 6.8 weeks ± 10.4, compared to 3.4 (SD 4.1) and 1.5 (SD 1.7) following first and last PNI, respectively. The difference between first PNI and RFA was not statistically significant (p = 0.64) but was significant between last PNI and RFA (p = 0.02). At three months post-RFA, 40% of patients reported improved quality of life and decreased pain medication usage.

Conclusions: CT-guided pudendal nerve ablation is well tolerated and can provide pain relief similar to or better than perineural injection with the potential for longer lasting effect, particularly after the benefits of repeat PNI begin to dissipate.

Abstract No. 581

Microwave ablation of osteoid osteomas using a gas-cooled probe: initial technique and results

Z. Igbinoba1, M. Singh2, A. Birney2, V. Bishay2, M. Ranade2, R. Patel2, E. Kim2, F. Nowakowski1, R. Lookstein2, A. Fischman2; 1Columbia College of Physicians and Surgeons, New York, NY; 2Icahn School of Medicine at Mount Sinai, New York, NY

Purpose: To evaluate safety, technique and clinical outcomes of microwave ablation (MWA) of osteoid osteoma (OO) using a gas-cooled probe.

Materials: A retrospective review of all CT-guided MWA performed for symptomatic OO from 10/2016 to 9/2017 was performed. A 13g Arrow OnControl (Teleflex, NC) bone drill access needle was used to provide coaxial access to the lesion under general anesthesia. Biopsy was performed in all cases. A 17g gas-cooled MWA probe (PR 15, Neuwave Medical, Madison WI) was advanced into the coaxial system after biopsy was performed. Ablation was performed at 30W for 30 seconds for 3 cycles. Technical success (TS), clinical success (CS-de defined as complete resolution of pain at 4 weeks FU and cessation of NSAID use), lesion characteristics, patient demographics, and major and minor adverse events (AEs) up to 30 days were recorded.

Results: 6 lesions in 6 patients (mean age 16, age range 11-22, 4 male, 2 female) were identified. Lesion location included: tibia (n = 3) transverse process vertebral body (n = 1), calcaneus (n = 1) femoral head (n = 1). Mean lesion size was 9.5 mm (range, 5-18 mm). Biopsy confirmed OO in 4/6 cases. 1/6 was non-diagnostic. 1/6 was lamellar bone. TS was achieved in all 6/6 cases. CS was achieved in 4/4 cases. Mean FU time was 24 days (range, 4-53 days). 2 cases are pending FU visit. There were no AEs up to 30 days.

Conclusions: CT-guided MWA for symptomatic OO using a gas cooled probe is safe and feasible using a single probe with high TS and CS.
Microwave ablation of osteoid osteoma: safety and efficacy

V. Gioioso1, S. Reis1, S. Brejt1, S. Tulin-Silver1, D. Sperling1, J. Susman2, J. Weintraub1, D. Mobley3, 1New York Presbyterian Hospital–Columbia University Medical Center, New York, NY

Purpose: The purpose of this study was to evaluate the safety and efficacy of CT-guided microwave ablation (MWA) of osteoid osteomas. MWA induces cellular death via high intratumoral temperatures leading to coagulation necrosis. Complete nidus ablation can be achieved with a single microwave probe, compared to multiple probes in radiofrequency ablation.

Materials: An IRB approved retrospective study evaluated 24 patients with osteoid osteoma treated by CT-guided MWA from 2014 to 2017. Under general anesthesia, an 11-gauge access needle was placed under CT-guidance into the nidus identified on preprocedural imaging. Co-axial 13-gauge core biopsy samples were obtained and sent for pathologic analysis. A single PR microwave antenna ablation probe (Neuwave Medical) was placed in a coaxial manner into the nidus. Serial microwave ablations were performed, per protocol. Data including age and sex of patients, duration of symptoms, location and nidus size of the osteoid osteoma, length of procedure, resolution of pain and biopsy results were assessed. Technical success was defined as accurate positioning of the antenna within the nidus. Treatment efficacy was determined by the need for re-ablation and the elimination of pain caused by the lesion evaluated using visual analog score (VAS). Safety was assessed based on the complication rate (hematoma, infection).

Results: The 24 submitted biopsy specimens’ pathology reports were reviewed; 19 were consistent with osteoid osteoma and the remaining five specimens returned diagnoses of enchondroma, chondroblastoma, benign osteoblastic lesion, and (2) corticocancellous lesions. Five patients reported return of similar symptoms 5-20 months after the treatment. Two elected for surgical resection, 2 underwent a second, successful MWA, and 1 elected conservative management. One documented complication of a probe fracturing in the lesion during positioning required surgical removal of the probe tip as well as the osteoid osteoma due to continued pain. There were no documented postprocedural complications of postbiopsy or post-MWA hematoma or infection.

Conclusions: CT-guided microwave ablation is a well-tolerated, safe and effective treatment of osteoid osteoma.

Interventional radiology–operated endoscopy using the LithoVue disposable endoscope: approach, technical success, complications, and outcomes in 12 patients

N. Patel1, J. Chick2, J. Gemmets3, R. Srinivasa4; 1University of Michigan, Ann Arbor, MI; 2University of Michigan Health System, Ann Arbor, MI; 3University of Michigan Hospitals, Northville, MI; 4N/A, Ann Arbor, MI

Purpose: To describe the approach, technical success, complications, hospital length of stay, and costs of interventional radiology-operated endoscopy using the LithoVue disposable endoscope in 12 patients at a single institution.

Materials: 12 patients, 6 (50%) males and 6 (50%) females, with mean age of 57.3 years (range, 29-90 years) underwent interventional radiology-operated endoscopy using the LithoVue disposable endoscope. In all patients, initial attempts to complete the anticipated interventions with fluoroscopy alone were unsuccessful. As a result, a 14-French sheath was placed and through it a 9.5-French single-use flexible endoscope was placed in a coaxial fashion. 8 (67%) biliary, 2 (17%) urologic, and 2 (17%) gastrointestinal interventional radiology-operated endoscopy procedures were performed. Presenting indications for endoscopy included:

- Urgent-peritoneal dialysis catheter placement: outcomes of radiologic versus laparoscopic techniques
  A. Abdel Aal1, K. Mahmoud1, S. Moawad1, N. Erte1, B. Hamed2, D. Ali3, M. Massoud1, I. Shawali4, P. Rageeb5, A. Mokhtar3, A. Almehmi1; 1University of Alabama at Birmingham (UAB), Birmingham, AL; 2University of Alabama at Birmingham, Birmingham, AL; 3University of Alabama at Birmingham, Birmingham, AL; 4Kasr Al Aini, Cairo, Cairo; 5University of Alabama At Birmingham, Birmingham, AL

Conclusions: Radiologic placement of PD catheters offers a clinically effective alternative to laparoscopic placement in the urgent start setting, with similar catheter survival and complication rates.
ostium localization (5; 42%), clearance of debris (5; 42%), stricture treatment (1; 7%), and filling defect characterization (1; 7%). Technical success, procedure time, fluoroscopy time, contrast usage, hospital length of stay, complications, and equipment costs were recorded. Technical success was defined as the ability of endoscopy to achieve the intended procedural outcome.

**Results:** Technical success was 92% (11/12). 1 technical failure occurred in which the target ostium could not be cannulated with the endoscope. Mean procedure time was 107.1 minutes (range, 44-203 minutes). Mean fluoroscopy time was 23.6 minutes (range, 6.4-46.5 minutes). Mean contrast usage was 51.8 milliliters (range, 20-100 milliliters). Mean hospital length of stay was 1 day (range, 0-3 days). Mean equipment costs were $3,903.05 (range, $1,131.63-7,794.00). 1 complication, a perinephric hematoma that did not require additional intervention, was reported.

**Conclusions:** Interventional radiology-operated endoscopy is feasible with good technical successes and few complications. The ability to directly visualize internal structures is complementary to standard fluoroscopic-guidance. Additional studies are warranted.

### Table 1. Summary of IROE Procedures

<table>
<thead>
<tr>
<th>Patient</th>
<th>Anatomy</th>
<th>Indication</th>
<th>Technical Success</th>
<th>Procedure Time (min)</th>
<th>Fluoroscopy Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biliary</td>
<td>Debris/stone</td>
<td>Yes</td>
<td>60</td>
<td>26.2</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Locating ostium</td>
<td>Yes</td>
<td>86</td>
<td>36.1</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Debris/stone</td>
<td>Yes</td>
<td>166</td>
<td>28.1</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Debris/stone</td>
<td>Yes</td>
<td>153</td>
<td>17.9</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Debris/stone</td>
<td>Yes</td>
<td>122</td>
<td>6.4</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Stricture</td>
<td>Yes</td>
<td>139</td>
<td>41.7</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Characterization</td>
<td>Yes</td>
<td>76</td>
<td>11.5</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Debris/stone</td>
<td>Yes</td>
<td>203</td>
<td>33.8</td>
</tr>
<tr>
<td>9</td>
<td>Urologic</td>
<td>Locating ostium</td>
<td>No</td>
<td>126</td>
<td>46.5</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Locating ostium</td>
<td>Yes</td>
<td>71</td>
<td>11.8</td>
</tr>
<tr>
<td>11</td>
<td>Gastrointestinal</td>
<td>Locating ostium</td>
<td>Yes</td>
<td>39</td>
<td>13.9</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Locating ostium</td>
<td>Yes</td>
<td>44</td>
<td>9.3</td>
</tr>
</tbody>
</table>

---

**Abstract No. 585**

**Cryoadblation of low-flow vascular malformations: single-center experience and how to stay out of trouble**

R. Ramaswamy¹, O. Akinwande², A. Som³, C. Guevara; ¹Mallinckrodt Institute of Radiology, St. Louis, MO; ²Washington University School of Medicine in St. Louis, St. Louis, MO; ³Washington University in St. Louis, St. Louis, MO

**Purpose:** Evaluate the safety and efficacy of cryoadblation in the treatment of Venous Malformations (VM) and Fibroadipose Vascular Anomalies (FAVA). Provide technical guidance and tips on how to achieve adequate treatment coverage and avoid complications.

**Materials:** Retrospective review of consecutive patients with VM and FAVA that underwent cryoadblation to achieve symptomatic control. Eleven patients were included in this study. Clinical records, precryoadblation procedures, cryoadblation procedural details, preprocedural symptoms, clinical outcomes and complications were evaluated. Patients had an average age of 25 years (10-50 years) and underwent cryoadblation of 14 lesions (5 FAVA, 9 VM).

**Indications for treatment included pain, swelling, contracture, and focal tenderness. Technical success was defined as adequate iceball coverage of the lesion. Clinical success was considered complete if all symptoms resolved and partial if some symptoms persisted but did not necessitate further treatment.**

**Results:** Average follow-up was 301 days (7-886 days). Technical success was 100%. Nine of eleven patients had a complete response. Eight patients had undergone prior sclerotherapy with seven out of eight having a complete response. One FAVA patient had residual contracture however preprocedural pain resolved, one VM patient had residual mild pain that no longer required medications or treatment. Three complications were seen, two of which were superficial skin blisters that resolved with conservative management and one case of transient numbness which subsided.

**Conclusions:** Cryoablation, though technically complex in treatment planning, is safe and effective in the treatment of low-flow vascular malformations as primary therapy or after sclerotherapy.

---

**Abstract No. 586**

**Sclerotherapy for lymphoceles: factors predicting clinical success**

C. Stampe¹, M. Richards², S. Young³; ¹University of Minnesota, Minneapolis, MN; ²University of Minnesota, Department of Radiology, Minneapolis, MN; ³University of Minnesota, Edina, MN

**Purpose:** Lymphoceles are a common problem, especially in the post surgical setting. While benign, they frequently become symptomatic due to compression of adjacent structures. Definitive treatments are limited, with technically challenging surgical options associated with high morbidity. Percutaneous drainage with sclerotherapy has shown improved success rates as compared to drainage alone, and has emerged as initial treatment in some centers. However, more data is needed to support an optimal protocol and identify factors predictive of therapy failure. This retrospective review aims to determine efficacy of one institution’s protocol and identify factors predictive of treatment failure.

**Materials:** Between 1/1/2006 and 12/1/2016, 142 patients presented with symptomatic lymphoceles at a single academic institution. Of those, 55 were excluded because their lymphoceles...
resolved with simple drainage and 4 patients were excluded because they were lost to follow-up, leaving 85 lymphoceles in 83 patients as the subject of this review. The cohort had an average age of 57 years and consisted of 27 men (32.5%) and 56 women (67.5%). Data pertaining to the cause of lymphoceles, symptoms associated with lymphocele, treatment length, treatment protocol, and clinical/imaging outcomes of sclerotherapy were collected.

**Results:** There were 19 clinical failures, making the clinical success rate 77.4% (65/84). Clinical failures, as compared to clinical successes, were treated for a statistically significant longer period of time (98.7 days vs 40 days) and had a higher volume of initial fluid output (502.8 cc vs 215.7 cc). Conversely, there was no difference in the largest single dimension size (12.1 cm vs 10.2 cm).

**Conclusions:** Sclerotherapy used to treat lymphoceles refractory to drainage alone had a high clinical success rate. Higher initial volume of output and requiring longer length of treatment may portend a higher likelihood of clinical failure.

---

**Abstract No. 587**

**Technical success and diagnostic yield of image-guided percutaneous pancreas transplant biopsy**

J. Wan, T. Morgan, L. Truong, L. Poder, S. Weinstein, M. Kohi, V. Feldstein; 1University of California, San Francisco, San Francisco, CA; 2University of California, San Francisco, San Francisco, CA

**Purpose:** To assess biopsy technique, technical success rate, diagnostic yield, and complication rates of image-guided percutaneous biopsies of pancreatic transplants.

**Materials:** This is a retrospective study of 117 patients (49% M) with median age 41 (19-61) referred for image-guided percutaneous biopsy of pancreas transplants between 01/01/1998 and 07/01/2017. Biopsies were performed with ultrasound (US) (n = 132) or computed tomography (CT) (n = 7) guidance using 16G or 18G spring-loaded core biopsy devices. Technical success was defined as completion of planned biopsy by obtaining core specimens. Biopsy results were classified as diagnostic (normal or rejection) or non-diagnostic based on review of histopathology reports. Technical success rates, diagnostic yields, and complication rates were evaluated.

**Results:** Image-guided percutaneous biopsies of 180 pancreas transplants (98 simultaneous pancreas-kidney, 51 pancreas after kidney, 31 pancreas transplant alone) were requested to assess for allograft rejection. Elevated serum amylase was the most common biopsy indication, followed by combined elevated serum amylase and lipase, and routine 3-month post-transplant protocol biopsy. 139 biopsies were performed; 41 cases were deferred with a majority due to inadequate percutaneous access by ultrasound (6 of these were subsequently performed under CT guidance). 100% of the attempted biopsies were technically successful. 126 biopsies (90%) were diagnostically successful yielding findings of rejection or no rejection. No significance difference in diagnostic yield was found between 16G versus 18G biopsy devices (p = 0.16). Subgroup analysis by biopsy indication found a combined elevated serum amylase and lipase to be statistically significant for histopathology demonstrating rejection (Odds Ratio 4, p = 0.03). No major complications occurred; 10% developed minor complications (small clinically insignificant arteriovenous fistulas or post-biopsy hematomas). No biopsies resulted in death or loss of allograft.

**Conclusions:** Image-guided percutaneous pancreas transplant biopsies have a high technical and diagnostic success rate without major adverse events.

---

**Abstract No. 588**

**Nodal lymphangiogram and embolization for the treatment of postoperative lymphoceles**

R. Charalel, O. Akinwande, C. Guevara, S. Kim, D. Picas, R. Ramaswamy, J. Chick; 1Weill Cornell Medicine, New York, NY; 2Mallinckrodt Institute of Radiology, St. Louis, MO

**Purpose:** To investigate safety and efficacy of nodal lymphangiogram and embolization as treatment for postoperative lymphoceles.

**Materials:** Retrospective review of 10 consecutive patients that underwent nodal lymphangiogram ± embolization as treatment for postoperative lymphoceles at a single academic medical center to date from December 2016 to August 2017. Patients included had a high output lymphocele with greater than 100 mL/day and had undergone standard of care treatment with drain placement ± sclerosis. Patients that had a lymph node dissection were excluded. Nodal lymphangiogram was performed with lipiodol via most prominent lymph node to demonstrate lymphatic ducts feeding the lymphocele. N-butyl cyanoacrylate diluted with lipiodol embolization was performed of prominent ducts feeding the lymphocele (1:2 ratio) and supplying lymph node (1:8 ratio). The primary endpoint was time to drain removal. Patients were monitored for complications.

**Results:** The average patient age was 62 years old with 5 males and 5 females. 10 patients underwent nodal lymphangiogram and 8 had accompanying embolization following a course with an indwelling drainage catheter. In the two patients that did not undergo embolization a feeding lymphatic duct could not be identified. Pre-procedure drains were present for an average time of 29 days and alcohol sclerosis had been performed an average of 1.67 times. The average drain output was 420 mL per day. Following nodal lymphangiogram ± embolization, the average time to drain removal was 12.2 days. One patient had a complex preprocedure course including recurrent lymphocele infections and developed concern for repeat infection postprocedure, treated with antibiotics. There were no other adverse events over an average followup time of 147.60 days. Following drain removal there were no cases of lymphocele recurrence.

**Conclusions:** Nodal lymphangiogram and embolization serves as a safe and effective treatment for postoperative lymphoceles when sclerosis fails. It can accelerate the process of drain removal which has implications of improved quality-of-life and cost benefit.

---

**Abstract No. 589**

**Vascular and lymphatic complications following thoracic duct cannulation: experience in 58 patients**

J. Bundy, R. Srinivasa, J. Gemmets, A. Hage, B. Majdalany, M. Khaja, W. Saad, J. Chick; 1N/A, Grand Rapids, MI; 2University of Michigan Medical
Purpose: To report the incidence of vascular and lymphatic complications following transabdominal thoracic duct cannulation.

Materials: 58 patients, including 30 (51.7%) males and 28 (48.3%) females, with mean age of 53.8 years (range, 44 days-87 years) underwent attempted thoracic duct cannulation between December 13, 2013 and August 28, 2017 (1,354 days). Patients presented with chyle leak in the chest (n = 40; 69%), abdomen (n = 9; 15.5%), neck (n = 8; 13.8%), and pelvis (n = 1; 1.7%). All patients underwent inguinal intranodal pelvic lymphangiography. Vertebral body level and geographic access into the lymphatic system, needle gauge, additional access for treatment, technical success, embolization performed, immediate complications, vascular and lymphatic complications, and follow-up duration were recorded. For all patients with attempted thoracic duct cannulation, postprocedure imaging, at 2 time points, if available, was reviewed to identify arterial, venous, and lymphatic complications.

Results: Access into the lymphatic system was obtained at L1 (n = 21; 36.2%), T12 (n = 17; 29.3%), L2 (n = 14; 24.1%), L3 (n = 3; 5.2%), T11 (n = 1; 1.7%), L4 (n = 1; 1.7%), and L5 (n = 1; 1.7%). Lymphatic access was achieved in the center (n = 28; 48.3%), right (n = 16; 27.6%), or left (n = 14; 24.1%) of the vertebral body, 21, 22, and 25-gauge needles were used in 45 (77.6%), 12 (20.7%), and 1 (1.7%) patients. Arm venous and percutaneous supraclavicular access were achieved in 15 (25.9%) and 8 (13.8%) patients. Cannulation of the thoracic duct was achieved in 52 (89.7%). Embolization, shearing of the access wire in 2 (3.4%) patients. Analysis of initial follow-up imaging in 49 (84.5%) patients revealed inferior vena cava thrombosis and a perinephric lymphatic collection. A second follow-up imaging study showed no additional complications. 1 (1.7%) patient developed a pulmonary embolism in the study period.

Conclusions: Complications of thoracic duct cannulation are low. Inferior vena cava thrombosis, renal vein thrombosis, and development of a perinephric lymphatic collection were seen.
hyperhidrosis was 69% (20/29). Of 29 patients, 9 (31%) failed initially and received a second treatment (7 bilateral, 2 unilateral). One patient had recurrent symptoms after two treatments and received a third, unilaterally. Following sympatholysis there were 3 cases of transitory Horner syndrome (10%), 1 case of intercostal neuralgia (3%), and 7 cases of compensatory hyperhidrosis (24%).

**Conclusions:** CT-guided percutaneous sympatholysis with EtOH is safe and effective with primary success rate of 69%. Compensatory hyperhidrosis, the most common complication, was seen in 24%. Of the major complications encountered, no permanent neurologic damage was seen.

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sweating is never noticeable and never interferes with daily activities</td>
</tr>
<tr>
<td>2</td>
<td>Sweating is tolerable but sometimes interferes with daily activities</td>
</tr>
<tr>
<td>3</td>
<td>Sweating is barely tolerable and frequently interferes with daily activities</td>
</tr>
<tr>
<td>4</td>
<td>Sweating is intolerable and always interferes with daily activities</td>
</tr>
</tbody>
</table>

**Abstract No. 592**

**How many VCF patients were exposed to elevated mortality risk from the diminution in vertebral augmentation referrals?**

K. Ong1, D. Beall2, E. Lau3, M. Frohbergh1, J. Hirsch4; 1Exponent, Inc., Philadelphia, PA; 2Clinical Radiology of Oklahoma, Oklahoma City, OK; 3Exponent, Inc., Menlo Park, CA; 4Massachusetts General Hospital, Boston, MA

**Purpose:** Debate about the effectiveness of vertebral augmentation followed the 2009 Kallmes/Buchbinder vertebroplasty (VP) studies. Diminished augmentation volume ensued, though many still considered augmentation to be effective (Lindsey 2013). With the lower mortality risk for balloon kyphoplasty (BKP) and VP patients than non-surgically managed (NSM) patients (Eddin 2015), we evaluated the post-2009 decrease in BKP/VP volumes and estimated how many patients were exposed to elevated mortality risk.

**Materials:** The 100% U.S. Medicare dataset (2005-2014) was used to evaluate the annual VCF prevalence and augmentation volume. A logarithmic rate was fitted to the augmentation rate and BKP to VP ratio from 2005-2009 to project the corresponding levels in 2010-2014. Decrease in BKP/VP volumes in 2010-2014 was estimated from the difference in projected and actual rates/ ratios. A second method (uniform rate; average of 2007-2009) was also used. The absolute mortality risk of NSM patients and their relative risk compared to BKP/VP patients from 2010-2014 were used to estimate the extra lives lost due to the BKP/VP volume

**Results:** 2,129,769 VCF patients were identified between 2005-2014. BKP/VP utilization was 20% in 2005, peaked at 24% in 2007-2008, and declined to 14% in 2014. Despite the overall decline, for each VP procedure, 1.2 BKPs were performed in 2005 which increased to 2.2 BKPs in 2009, and 3.7 in 2014. Projected BKP/VP utilization was estimated at 25.7% (logarithmic rate) and 23.6% (uniform rate) in 2014, with a corresponding BKP/VP ratio of 2.6. Compared to projections, estimated diminution in augmentation volume in 2010-2014 was 59,389 to 75,452. Because NSM patients had a higher mortality risk of 28% (5 years) to 52% (1 year) and 19% (5 years) to 34% (1 year) compared to BKP and VP patients, respectively (p<0.001), it was estimated that 5,287 to 6,814 extra lives may have been lost due to the reduction in augmentation volume in 2010-2014.

**Conclusions:** Referral/treatment pattern changes may have led to approximately 59,389 to 75,452 fewer BKP/VP patients in 2010-2014. Due to the higher mortality risk for NSM patients, an estimated 5,287 to 6,814 extra lives may have been lost.

**Abstract No. 593**

**Efficacy of a vertebral augmentation system used for bone remodelling as treatment of vertebral fractures**

S. Marcia1, E. Piras2, A. Spinelli2, S. Marin2, L. Saba3; 1Radiology SS Trinita’ Hospital Assl Cagliari, Cagliari, Italy; 2Radiology SS Trinita Hospital Assl Cagliari, Cagliari, CA; 3Radiology University of Cagliari, Cagliari, CA

**Purpose:** The aim of this study was to evaluate the effectiveness and safety of a bone remodelling system in the treatment of painful vertebral compressive fractures (VCFs).

**Materials:** Thirty consecutive patients with painful vertebral compressive fractures underwent the bone remodelling (Tektona®, SpineArt, CH) procedure. Patients had been previously evaluated by clinical examination and X-ray, CTms and MRI-T2wSTIR. All the procedures were executed with local anaesthesia and a bilateral approach under digital fluoroscopic guidance. In total, 37 vertebrae were treated. Clinical evaluation and assessment of pain using a 11-point visual analogue scale (VAS, 0–10) were performed at baseline, immediately after the procedure, at 6 and 12-month; disability and health status by means of ODI and SF36 were also evaluated. Vertebral height (VH) restoration by vertebral body volume (VBV) calculation with CTms was assessed before (pre-) and immediately after the procedure (post), as well as vertebral heights (anterior, middle and posterior VHs) and the local (LK) and regional (RK) kyphosis angles.

**Results:** We obtained a progressive reduction of the pain in all the patients we evaluated at 6-m (30 patients) and at 12- m (21 patients) (VAS pre: 7.6, post: 2.8, 6M: 2.1, 12M: 2.9), improvement of functions (ODI pre: 55.5, 6M: 22.3, 12M: 27.2) as well as an average improvement of 15% in SF-36 Physical Health score (PHs pre: 40.6%, 6M: 55.6%) at 6-m and of 2% (PHs at 12M: 42.5%) at 12-m. We observed a good height restoration (middle VH: 13.64mm, post: 15.25mm, 12M: 18.36mm, difference: 4.72mm), a good increase in the volume of the vertebral bodies (VBV pre: 21.61cm³, post: 23.08cm³, 12M: 23.42cm³, difference: 1.81cm³). The correction of local kyphosis have been checked immediate postoperatively and at 12-m and the kyphosis correction was confirmed, as follows: an average LK decrease of 1.57° and an average RK decrease of 2.6°. No major complications arose.

**Conclusions:** From our study, the use of bone remodelling system was found to be safe and effective in the treatment of painful vertebral fractures, providing pain relief and anatomical restoration.
Abstract No. 594

Nusinersen for spinal muscular atrophy: the era of interventional radiology molecular therapy is here
S. Willard1, D. Aria1, C. Schaefer2, R. Kaye1, R. Towbin3;
1Phoenix Children’s Hospital, Phoenix, AZ; 2N/A, Scottsdale, AZ; 3N/A, Paradise Valley, AZ

Purpose: Spinal muscular atrophy (SMA) is a genetic disorder caused by mutations in the SMN1 gene resulting in muscle weakness and atrophy. The purpose of this study is to evaluate our initial experience with intrathecal administration of Nusinersen for treatment of SMA.

Materials: From March to July 2017, 13 patients with SMA types 1 or 2 have received a total of 31 intrathecal treatments using standard lumbar puncture technique. All procedures were performed under general anesthesia or local anesthetic only. The Hammersmith Infant Neurodevelopmental Evaluation tool was used to evaluate function and treatment response. The established protocol is 4 induction doses then every 4 months for life. Drug cost is $120,000/dose.

Results: Technical success without complication was achieved in all cases. Follow-up assessment via Hammersmith scoring has showed improvement in the first 3 patients that have completed the induction phase.

Conclusions: Nusinersen has ushered in molecular therapy to pediatric intervention. This genetically based treatment has shown gratifying results, but raises the dilemma of a high cost solution to a rare disease.

Abstract No. 595

Clinical parameters predictive of repeat endovascular interventions or stenting of Meso-Rex shunt-related stenosis
A. Johnston1, S. Baisiwala1, J. Green2, R. Superina2, J. Donaldson2, S. Rajeswaran2; 1Northwestern University Feinberg School of Medicine, Chicago, IL; 2Ann & Robert H. Lurie Children’s Hospital of Chicago, Chicago, IL

Purpose: Surgical creation of a Meso-Rex shunt may reduce or resolve portal hypertension secondary to extra-hepatic portal vein thrombosis. Stenosis of the surgical shunt may occur, although is often amenable to endovascular intervention. Shunt stenosis generally responds well to angioplasty in a single setting; however, there is a subset of refractory patients who may require repeat angioplasty and/or stent placement. Elevated shunt flow velocity, low platelets and ascites have been used as clinical markers of shunt dysfunction. Our study aims to delineate parameters among these markers which may predict which patients are more likely to require a repeat intervention.

Materials: IRB approved retrospective study of all children undergoing Meso-Rex shunt surgery at our institution from 2000-2016. Initial ultrasound and angioplasty measurements and laboratory data were evaluated for all children requiring IR intervention for shunt stenosis. Chi-Square and Fisher tests were used for statistical analysis.

Results: Of the 115 total Meso-Rex shunt pediatric patients, 27 (mean age 8.4 years) required IR intervention for shunt stenosis, with 10/27 requiring multiple interventions. Clinical parameters independently predictive of repeat intervention included platelets $\leq 70 \times 10^3/\mu L$, moderate to severe ascites, and left portal vein peak systolic velocity $\geq 250$ cm/sec. 15/27 patients did not satisfy any of the criteria, and 14 of these patients were managed successfully via a single intervention ($p = 0.0008$). 12/27 patients satisfied at least one of the three criteria and 9 of these patients required repeat intervention ($p = 0.008$).

Conclusions: Stenosis of a surgically created Meso-Rex shunt is most often managed successfully via a single angioplasty procedure, although some patients may require repeat interventions for residual or recurrent stenosis. Our study describes three parameters predictive of need for repeat IR intervention: platelets $\leq 70 \times 10^3$ units/$\mu L$, left portal vein velocity $\geq 250$ cm/sec and moderate to severe ascites. Knowledge of these parameters may allow for improved procedure planning and counseling prior to a patient’s initial intervention.

Abstract No. 596

Ultrasound-guided lumbar puncture in pediatric patients: technical success and safety
D. Pierce1, G. Shivaram2, K. Koo2, D. Shaw2, K. Meyer2, E. Monroe2; 1University of Washington, Seattle, WA; 2Seattle Children’s Hospital, Seattle, WA

Purpose: When image guidance for lumbar puncture is required, fluoroscopy is the mainstay. Disadvantages of fluoroscopic guidance in pediatric patients include delivery of ionizing radiation and limited resolution of incompletely ossified posterior elements. By contrast, with ultrasound (US) guidance, the thecal sac, conus medullaris, and nerve roots can all be readily visualized with no exposure to ionizing radiation. Furthermore, US guidance allows for quantification of CSF prior to puncture. The current study aims to determine the technical success and safety of US-guided lumbar puncture in pediatric patients.

Materials: A retrospective review identified all patients referred to interventional radiology for image-guided lumbar puncture between June 2010 and June 2017. Patients who underwent lumbar puncture with fluoroscopic guidance alone were excluded. For the remaining procedures, technical success, defined as acquisition of cerebrospinal fluid, and procedural complications were assessed. 201 image-guided lumbar punctures (in which at least preliminary procedural US was acquired) were performed in 161 patients (median age 125 days, 58% male). 80 patients (43%) were referred for failed non-image-guided, landmark-based attempts.

Results: 196 (97.5%) patients in whom at least preliminary US was performed underwent US-guided lumbar puncture. Five procedures (2.5%) were not attempted after US assessment, either due to a paucity of cerebrospinal fluid or unsafe window for needle placement. Technical success was achieved in 187 (95.4%) of lumbar punctures attempted with US guidance. 177 (90.3%) were technically successful with US-guidance alone and an additional 10 (5.1%) were successful with US-guided thecal access and subsequent fluoroscopic confirmation. Three (1.5%) cases were unsuccessful with US guidance, but were subsequently successful with fluoroscopic guidance. Of the 80 previously attempted landmark-based lumbar punctures, 77 (96.3%) were successful with US guidance alone. There were no reported complications.
Purpose: To report technical success and clinical outcomes of thoracic duct embolization (TDE) in neonates.

Materials: 3 patients, 2 (66.6%) males and 1 (33.3%) female, underwent TDE between April 2017 and September 2017. Mean age was 3 weeks (range, 2–4 weeks) and mean weight was 2.9 kg (range, 2.0–4.4 kg). Indications for embolization, leak type, preoperative imaging, drainage appearance and output, site of cannulation, needles and wires used for cannulation, microcatheter type, embolic agent used, technical success, clinical success, complications, outcomes, and follow-up were recorded.

Results: Indications included: iatrogenic injury (n = 2; 66.6%) from congenital diaphragmatic hernia (n = 1; 33.3%) and tracheoesophageal fistula repair (n = 1; 33.3%), and idiopathic congenital chylous ascites (n = 1; 33.3%). Types of chyle leak included: chylothorax (n = 2; 66.6%) and chylous ascites (n = 1; 33.3%). Preoperative imaging included chest radiography in 2 patients and magnetic resonance lymphangiography in 1 patient. Drainage appearance was milky yellow in all patients with mean output of 272 mL/day (range, 48–653 mL/day). Cannulation site was at L3 in 2 patients and L4 in 1 patient. 21-gauge, 7 cm micropuncture needles, 0.018-inch Transend wires, and 2.4-French microcatheters were used for catheterization in all patients. Embolic agents used included glue and coils (n = 1), glue and sotradecol (n = 1), and glue only (n = 1). Technical success of cannulation of the thoracic duct was 100%. Clinical success was 66.6% with 2 patients having complete resolution of chylothorax after the procedure. The patient with congenital chylous ascites had successful embolization, but developed additional proximal leaks requiring surgical mesh placement with clinical resolution. 1 complication was encountered with non-target embolization of glue to the coronary sinus, right atrium, and pulmonary arteries which was salvaged with a snare and surgical pulmonary embolectomy. All patients were alive with clinical resolution of chyle leak at mean of 72 days (range, 5–168 days).

Conclusions: Neonatal thoracic duct embolization is feasible with high technical and clinical success. Lymphatics may be accessed at lower levels than that in adults.

Abstract No. 599

Time-driven activity-based costing in interventional radiology: a pilot study

Y. Pershad1, H. Albadawi1, S. Naidu1, M. Knuttinen1, J. Kriegshauser1, R. Oklu1; 1Mayo Clinic Arizona, Phoenix, AZ

Purpose: Healthcare represents 17% of the US’s GDP and is riddled with waste. Before managing or improving high costs, more effective methods are needed to measure them. Time-driven, activity-based costing (TDABC) aims to measure true costs throughout a patient’s care cycle using two inputs: (1) the amount of time that specific resources (e.g., physician, equipment, etc.) are used, and (2) their cost rate per unit time. This pilot study aims to apply this empirical costing tool to characterize resource allocation in an interventional radiology (IR) department at a tertiary care center. Our ultimate goal is to determine opportunities for improving efficiency of IR procedural delivery.

Materials: Two IR rooms from staff arrival (7:30) to dismissal (17:30) for 6 randomly selected, non-consecutive days were observed; 66 procedures were performed over 180 hours of observation. The time-points measured included preparation time,
attending time spent, procedural time, room-turn-over time, and idle time. The staff did not know the independent observer was tracking these variables. Second, we modeled potential solutions and used cost rates to calculate the effect of improving inefficiencies. 

**Results:** Average daily room usage, peak-time room usage, idle time, procedural time, and room-turn-over time were computed revealing significant opportunities for improvement. Moreover, room usage fluctuated throughout the day, with low usage from 7:30 to 8:30, lunch time and 15:30 to 17:30. Not counted as idle, time spent waiting for the operator with the patient on the table averaged was also computed averaging 18.8 min per case. Extensive modeling was performed demonstrating that a reduction of idle time and attending waiting time by 10% could add approximately 500 cases per year. 

**Conclusions:** Idle time between cases is large; staggering lunch could reduce waste and operator-specific scheduling could eliminate overestimations of procedure time. Improved communication with physicians would prevent waiting and improve care delivery. Such simple observational studies demonstrate the importance of measuring waste to identify solutions and predict quantitative effects. TDABC is a critical first step to improving IR efficiency.

**Abstract No. 600**

**Lower extremity endovascular revascularization for Medicare beneficiaries**

M. Said\(^1\), B. Roudsari\(^2\), R. Pillai\(^2\), C. Vu\(^2\); \(^1\)UC Davis School of Medicine, Sacramento, CA; \(^2\)UC Davis Medical Center Department of Radiology, Sacramento, CA

**Purpose:** This study evaluates the state-level practice of vascular surgery (VS), interventional cardiology (IC), and interventional radiology (IR) in lower extremity endovascular revascularization (LEER) for Medicare beneficiaries.

**Materials:** We used the 2015 Centers for Medicare & Medicaid Services’ (CMS’s) “Provider Utilization and Payment Data Physician and Other Supplier Public Use File.” The database includes type of service, provider-specific inpatient and outpatient charges, and actual Medicare reimbursements for each CPT code. LEER-specific CPT codes were extracted from this database.

**Results:** 4,113 providers submitted claims for iliac (733), femoropopliteal (2184), and tibioperoneal (1196) endovascular revascularization. Nationwide, in the inpatient setting, VS performed approximately 52% of the procedures followed by IC (32%) and IR (8%). In the outpatient setting, the corresponding numbers were 46%, 36% and 13%, respectively. Florida (443), Texas (389) and California (341) had the highest number of providers. In these three states 53%, 40%, and 60% of LEERs were performed in an outpatient setting, respectively. VS, IC, and IR performed 58%, 27%, and 11% of inpatient LEERs in Florida. California followed a similar trend as Florida. However in Texas, VS, IC, and IR performed 42%, 40% and 7%, respectively. Nationwide, the average submitted physician fees by VS, IC, and IR were $4300, $3,500, $3,600 with actual reimbursements of $370, $406, and $390, respectively. The average submitted charges for outpatient LEER by VS, IC, and IR were $23,000, $23,000, and $22,000 with reimbursements of $6,700, $6,700, and $6,000, respectively. There was significant interstate variability in the submitted charge of care by the different specialties, but there was minimal variability in the actual Medicare reimbursements.

**Conclusions:** This study demonstrates the current practice of VS, IC, and IR in LEER and summarizes the state-level variability in the submitted charge of care and actual Medicare reimbursements.

**Abstract No. 601**

**Modeling costs comparing same day discharge and overnight stay following chemoembolization**

A. Khosla\(^1\), M. Khalaf\(^2\), M. AbdelRazek\(^2\), N. Kothary\(^3\); \(^1\)Stanford, Mountain View, CA; \(^2\)Stanford University School of Medicine, Stanford, CA; \(^3\)Stanford University Medical Center, Stanford, CA

**Purpose:** Recent studies advocate same-day discharge for patients undergoing transarterial chemoembolization (TACE) for hepatocellular carcinoma (HCC) as an opportunity for cost-savings. Herein, we model the projected costs at a tertiary hospital for same-day discharge versus that for overnight observation for TACE.

**Materials:** Patients who had undergone TACE at a west coast tertiary hospital from 2014-2016 served as the basis for the model (508 total patients). Assumptions included a 4-hour observation in the interventional radiology (IR) postprocedure unit (PACU) for the same-day discharge cohort and hospitalization in a non-monitored unit for the overnight observation cohort. Labor costs per hour and medication costs were calculated utilizing published cost calculations. Emphasis was placed on marginal costs rather than fixed costs.

**Results:** Labor charges from utilized nursing care were the primary drivers of cost. While same-day discharge utilized fewer nursing hours, the higher level of care and lower nurse-to-patient ratio, incurred higher costs. Utilizing this model, same-day discharge patients incurred a decreased marginal cost of $124 per visit. Extrapolating based off the model, same day discharges would save an institution $61,628 over a two-year period. Further, unrelenting pain and nausea can necessitate conversion of a same-day discharge to an overnight observation. At a 10% conversion, the cost-savings would be $48,202 and at 41% conversion, the savings would be negated. A model that allowed for 1-hour PACU monitoring and 3 hours of inpatient observation would be optimal and would result in additional $21,301 of savings.

**Conclusions:** Same day discharge results in cost savings, however not as substantial as one would expect in a tertiary care center. Additionally, a high conversion rate from same day discharge to inpatient observation would negate the savings from same day discharge. A model that incorporated PACU stay and partial admission would result in the maximum savings.

**Abstract No. 602**

**Analysis of procedural reimbursement in interventional radiology: experience of an academic tertiary care medical center**

S. Mirzan\(^1\), A. Harbaugh\(^1\), K. Pian\(^1\), R. Liu\(^1\); \(^1\)Massachusetts General Hospital, Boston, MA

**Purpose:** Variation in payment for procedural reimbursement can significantly impact profitability. We sought to better understand
Abstract No. 603

Utility or futility: is the routine preoperative evaluation of patient coagulation status essential prior to tunneled subcutaneous port placement?
R. Braun1, E. Aaltonen1, J. Gross1, J. Horn1; 1NYU Langone Medical Center, New York, NY

Purpose: To determine whether routine preoperative evaluation of patient coagulation status, as reflected by the calculated International Normalized Ratio (INR), is necessary prior to placement of a tunneled subcutaneous port.

Materials: We conducted a retrospective analysis of tunneled subcutaneous port placements performed by interventional radiology in the ambulatory setting at a single institution over a 6-month period from March to September 2017. The INR values at time of initial outpatient referral, as well as any subsequent preoperative coagulation testing, were compiled from the electronic medical record. Any INR abnormalities, defined as a value greater than 1.5, were then cross-referenced with specific patient past medical history.

Results: A total of 263 patients had subcutaneous ports placed during the 6-month study period (29.7% male, mean age 59). INR testing was performed within 30 days of port placement for every patient, as per departmental protocol based on the Society of Interventional Radiology (SIR) guidelines for management of patient coagulation status. Of the 263 port placements, only 4 patients (1.5%) demonstrated INR values above the threshold limit: two patients were on Coumadin therapy for chronic thromboembolic disease and atrial fibrillation respectively, one patient was on Apixaban (Eliquis) for atrial fibrillation and one patient had known non-alcoholic steatohepatitis (NASH) cirrhosis.

Conclusions: The incidence of an abnormal INR in patients is very low. Within the study period, only 1.5% of patients undergoing tunneled subcutaneous port placement demonstrated a coagulation abnormality on routine preoperative testing. All noted abnormalities were explained by a review of the individual patient medical history; specifically, these patients were either on anticoagulation or had known hepatic dysfunction. These findings suggest that the majority of patients do not require routine preoperative testing of coagulation status and that a preprocedural INR can be obtained on a case-by-case basis as predicted by relevant patient medical history.

Abstract No. 604

Simulation in pediatric interventional radiology environment: what lessons are we learning? R. Shaikh1; 1Boston Childrens Hospital, Boston, MA

Purpose: Interventional radiology (IR) space is a complex environment involving several personnel with different clinical and technical skills such as interventional radiologists, anesthesiologists, nurse practitioners, nurses and technologists. In pediatric IR, there is an intricate parental/guardian involvement in the care of minors. The physical setting also requires a close integration of humans and technical hardware (digital subtraction angiography table, ultrasound machine, laser machine, anesthesia machine etc.). Most patients are also critically ill. These variables make it extremely important to create an environment which is synchronous and safe for patient care. A periodically occurring simulation was initiated in IR at our institution to bring together intelligent, improvement-oriented personnel to develop a team based practice in the interest of patient and employee safety.

Materials: Every simulation exercise involved real-time enactment of an interventional procedural scenario coordinated by simulation facilitators. Scenarios were provided to a selected team consisting of an interventional radiologist (attending and fellow), anesthesiologist (attending and fellow), IR nurse, IR technologist. Interactive trainer mannequins were used as patients during the procedures. Participants were placed in a real life like situation. Scenario enactment was followed by debriefing session to the participants.

Results: Several important issues such as team communication, problem recognition and management, team integration were uncovered during these simulation sessions. Possible solutions were discussed. These recommendations were summarized and provided to divisional administration to affect policy changes.

Conclusions: IR simulation program is very essential in building a safe psychological and physical environment for patients and the IR personnel.
Abstract No. 605

Minimizing the uncertainty when you are expecting the unexpected: monitoring radiation exposure during pregnancy
Y. Zhang¹, T. Rashid², C. Shilagani¹, M. Mozzor³, M. High⁴; ¹Westchester Medical Center, Valhalla, NY; ²N/A, New Rochelle, NY; ³New York Medical College, Valhalla, NY

Purpose: Women are underrepresented in IR, while maybe partially due to fear of radiation exposure during child-bearing period¹. For those who choose IR as a career, they may face the challenge of being able to stay productive during pregnancy and receiving the appropriate support from their colleagues who may lack the in-depth understanding of radiation risks relating to pregnancy. We will review and compare the commonly used dosimeters including the real-time dosimeter to provide comprehensive understanding of their sensitivity, accuracy and consistency in monitoring fetal radiation exposure and to provide additional insights to the appropriate dosimeter choice and radiation protection practice.

Materials: 1. Literature review of the current commercially available personnel dosimeter types which may be used to monitor fetal and maternal dose during pregnancy. 2. Compare the real-time fetal dosimeter reading to the estimated dose from maternal real-time dosimeter reading during commonly performed IR procedures. 3. Compare the fetal dose report from the standard optically stimulated luminescence dosimeters (OSL) to calculated dose from maternal dose record during pregnancy.

Results: 1. Preliminary result demonstrates the high sensitivity of both standard OSL dosimeter and real-time dosimeter wearing under the lead apron for providing fetal dose monitoring. 2. Real-time dosimeter provides instant dose report but is inferior to OSL in consistency and accuracy.

Conclusions: Fetal radiation exposure, while negligible per procedure, accumulative dose contributes to stochastic risk. Real-time dosimeter can provide instant awareness of dose rate and minimize unnecessary anxiety and warrants instant modification in radiation safety practice. Standard dosimeters provide accurate however delayed accumulate dose report to ensure compliance with radiation safety guidelines.

Abstract No. 606

Respiratory compromise events in hospital interventional radiology procedures using procedural sedation
R. Urman¹, A. Ozols², C. Flynn³; ¹Brigham and Women’s Hospital, Boston, MA; ²Medtronic, Phoenix, AZ; ³Medtronic, Mansfield, MA

Purpose: Respiratory Compromise (RC) is a state in which there is a high likelihood of decompensation into respiratory insufficiency, respiratory failure or death. Our goal was to determine the incidence of in-hospital acute respiratory events for patients undergoing interventional radiology (IR) procedures using procedural sedation.

Materials: A retrospective analysis was performed using the Premier Database CY2014 over one year in adult patients, >18 years. Hospital inpatient IR procedures were identified by ICD-9 procedure codes and grouped into 12 different therapeutic categories. Acute respiratory compromise events were identified using ICD-9 codes for respiratory insufficiency, respiratory arrest, and respiratory failure, the CPT procedure code for emergency intubation, and naloxone administration. Death was identified per therapeutic category by discharge disposition status. Procedural sedation was identified by opioid, benzodiazepine, barbiturate, or IV anesthetic use and no accompanying anesthesia CPT code. We excluded subjects with inhaled anesthetic use.

Results: There were 120,562 acute respiratory events identified out of 1,077,712 hospital IR sedation procedures, representing a combined average RC event rate of 11.2%, and a combined average death rate of 4.7% across all 12 therapeutic categories. The incidence of RC events ranged from a low of 4.1% to a high of 18.9%, depending on therapeutic IR procedure category. The top three RC rates by category were clot management, neuro-interventional, and vascular access interventions at 18.6%, 16.7%, and 13.8% respectively. The highest death rates observed were in clot management, 9.1%, vascular access, 6.6%, and GI interventions, 4.1%. The lowest RC event rates were observed in urological interventions, 6.4%, vertebroplasty/kyphoplasty, 5.2%, and oncology, 4.0%, with a death rate of 1.6%, 0.5%, and 0.7% respectfully.

Conclusions: Given the substantial rate of RC events observed in this study, better strategies for the prevention and management of respiratory compromise events in IR sedation procedures is warranted, and if addressed would likely improve overall patient outcomes and result in substantial healthcare savings.

Abstract No. 607

Incidence of radiation skin reaction after fluoroscopically guided interventions (FGI) during which the patient is exposed to reference air kerma (Ka,r) exceeding 5 Gy
K. Burns¹, S. Huang¹, A. Jones¹; ¹MD Anderson Cancer Center, Houston, TX

Purpose: To determine the incidence of radiation skin reaction occurring in patients undergoing FGI resulting in Ka,r exceeding our substantial radiation dose level (SRDL) of 5 Gy in IR.

Materials: Since July 2009 we have followed up with patients undergoing FGI who experience Ka,r exceeding our SRDL, which is 5 Gy as recommended by NCRP. With waiver of informed consent, we reviewed data from procedures resulting in Ka,r > 5 Gy since July 2009. Results of follow-up; information about skin conditions; wound healing; patient size, including AP thickness and BMI; and factors known to affect radiosensitivity, including tobacco use, diabetes, chemotherapy, and previous skin irradiation were reviewed. Dose information included cumulative Ka,r from all procedures within 6 months before and after the procedure exceeding the SRDL and the biologically effective dose (BED).

Results: 71 patients experienced Ka,r > 5 Gy in a single procedure. In these patients, 137 procedures were performed within a 6 month window, including repeated procedures for hepatic embolization, visceral embolization for bleeding, AVM embolization, and IVC filter retrieval. The maximum Ka,r from a single procedure was 12.1 Gy, the maximum cumulative Ka,r was 21.4 Gy, and the maximum BED was 12.8 Gy. Cumulative Ka,r
radiation skin reactions were noted in non-surgical patients. A single would healing complication was observed after presurgical embolization of a sacral tumor with $\text{Ka,r} = 6.4 \text{ Gy}$. However, the patient was a current tobacco user, malnourished, experienced massive blood loss, and was immobile during a prolonged ICU stay.

**Conclusions:** Radiation skin reaction is very rare, even for repeated procedures with high cumulative $\text{Ka,r}$ values. This indicates that very high single doses of radiation are required to cause skin injury in most patients and that when procedures are repeated or staged with sufficient interval time, fractionation is protective against skin injury.

---

**Abstract No. 608**

**Value of performing outpatient CT-guided percutaneous lung biopsy at a large, tertiary care center after unsuccessful outside hospital biopsy attempt**

T. Connors¹, S. Sabir¹, A. Tam¹, K. Ahrar¹, R. Sheth¹, S. Gupta¹, J. Steele¹; ¹MD Anderson Cancer Center, Houston, TX

**Purpose:** To determine the value of performing outpatient CT-guided percutaneous lung biopsy (CTLB) at a large, tertiary care center after unsuccessful outside hospital biopsy attempt.

**Materials:** Retrospective review of 402 consecutive patients undergoing outpatient CTLB at MD Anderson Cancer Center for the 120-day period ending June 15, 2017 was undertaken. The reason for biopsy was determined based upon the interventional radiology preprocedure clinic note. Demographics, procedure and imaging variables, complications, and pathology results were collected.

**Results:** Of the total number of patients biopsied during this period, 5% (20/402) were either denied biopsy at an outside hospital (OSH) or had an inadequate biopsy result which precluded treatment decision planning. 3 patients were denied biopsy at OSH for high risk and/technical difficulty; 9 patients underwent repeat biopsy for prior non-diagnostic biopsy at OSH; and 8 patients underwent repeat biopsy for incomplete biopsy at OSH. The mean age was 66 years (15 – 90), 50.7% were female, and 17.2% had history of COPD. Median lesion size was 1.5 cm (0.5 – 9.4). Biopsy was performed with core in 98.0%, fine-needle aspiration (FNA) in 51.0%, and both core and FNA in 49.0% of cases. Median number of core samples was 3 (1 – 8) using a median 20-gauge (18 – 20) needle and median number of FNA samples was 3 (1 – 8) using a 22-gauge needle. Of these 20 patients, 3/20 (15.0%) developed PTX (CTCAE Grade 1) and 1/20 (5.0%) required chest tube placement for expanding PTX (CTCAE Grade 2). All 20 patients (100.0%) had a successful diagnostic biopsy based on histology and/or requested molecular testing.

**Conclusions:** 20 patients underwent CTLB at MD Anderson Cancer Center after unsuccessful outside hospital biopsy attempt. The advanced experience of providers allowed for aggressive biopsy sampling with complication rates within the expected thresholds of the institution and yielded meaningful pathology outcomes based on histology and/or requested molecular testing. On an annualized basis, this represents 60 previously unserved patients that could safely receive a diagnosis, demonstrating the value of higher level care centers in the broader healthcare value chain.

---

**Abstract No. 609**

**Imaging beyond PACS: documenting clinical photographs in the electronic medical record with a mobile application**

S. Berkowitz¹, F. Collares², J. Weinstein³, L. Nathanson¹, M. Ahmed⁴, ¹Beth Israel Deaconess Medical Center, Boston, MA; ²Beth Israel Deaconess Medical Center, Harvard Medical School, Newton, MA; ³Beth Israel Deaconess Medical Center, Newton, MA; ⁴Beth Israel Deaconess Medical Center/Harvard, Boston, MA

**Purpose:** Visual physical exam findings are essential in the pre- and postprocedure evaluation of many conditions treated through minimally invasive procedures performed by interventional radiologists. Clinical photographs help providers communicate and demonstrate the role of interventional radiologists as clinical consultants. The purpose of this study was to assess the usage frequency, among interventional radiologists, of a custom smartphone application for documenting clinical photographs in the electronic medical record.

**Materials:** A custom native application, PhotoConsult, was written for iOS devices to securely capture digital photographs at the point of care. The application was fully integrated with the IT infrastructure of the hospital and complied with all security policies and HIPAA regulations. The application can be installed on personal or hospital owned devices. Users log in with hospital authentication or fingerprint and select a patient by medical record number or by scanning a patient barcode. Photographs captured in the application are never stored on the users’ devices. Several photos can be captured in series. Photographs can be cropped, rotated, annotated and captioned. Photographs and captions are assembled into a PDF that is securely transmitted to the electronic medical record.

**Results:** During the trial period between September 2016 and 2017, 170 users across 26 departments took 3389 clinical photograph sets of 2138 patients. 10 users in the interventional radiology department took 84 sets of photographs. 33 (40%) of the IR photographs were taken before or after venous sclerotherapy to document response. 11 (13%) of IR images were taken from port sites to document wound-healing concerns. Photographs were taken of dialysis circuit aneurysms, catheter skin entry sites, facial swelling before and after SVC angioplasty, and IVC filters after removal.

**Conclusions:** Evaluation of physical exam findings is critical for the clinical practice of interventional radiologists. Documentation of findings in the electronic medical record can be streamlined with a secure mobile application.

---

**Abstract No. 610**

**Does an abnormal ultrasound study after TIPS correlate with TIPS dysfunction?**

K. Sniderman¹, S. Frosi Stella², F. Wong³; ¹Toronto General Hospital/University Health Network, Toronto, ON; ²Toronto General Hospital, Toronto, ON; ³Toronto General Hospital, Toronto, Ontario
**Purpose:** Stenosis within TIPS reduces its effectiveness to lower portal vein thrombosis (PH), increasing the risk of variceal bleeding/ascites. Reports have variably suggested both positive and negative correlations between abnormal duplex ultrasonography (DU) and TIPS dysfunction. At our institution, all TIPS patients with abnormal DU undergo angiographic/hemodynamic studies prior to shunt revision. This study examines the effectiveness of DU for surveillance after TIPS for PH with ascites.

**Materials:** A 12 year retrospective review of TIPS procedures for ascites was performed. Using Medical Imaging/IR databases, patients with abnormal DU studies were extracted; TIPS dysfunction on ultrasound was suggested by hepatopetal branch portal vein flow, marked focal increase in TIPS velocity, TIPS velocity 8mm Hg. The patients’ angiographic and hemodynamic records were compared with DU exams to determine the effectiveness of DU.

**Results:** 134 angiographic/hemodynamic studies were performed on 69 TIPS patients whose DU surveillance study suggested TIPS dysfunction. 71 had focal or diffuse TIPS stenosis (53% DU positive predictive value), and 63 had no stenosis (47% false positive rate). PSG (N = 128) was > 8 mm Hg in 72 studies (56% DU positive predictive value), and = < 8 mm Hg in 56 studies (44% false positive rate). Based on the angiographic/hemodynamic results, intervention was avoided in 42/134 (32%).

**Conclusions:** DU is not an effective non-invasive surveillance tool after TIPS, since there is no positive correlation between abnormal DU and angiographic/hemodynamic studies. However, since there is presently no better non-invasive test demonstrating TIPS dysfunction, angiographic/hemodynamic studies remain necessary to confirm the results of DU studies prior to intervention.

---

**Abstract No. 611**

**Left-sided portal hypertension in the presence or absence of splenic vein thrombosis: a single tertiary center experience**

L. Walker, D. Kumari, T. Bochnakova, E. McLoney, C. Sutter, J. Davidson, L. Patel, S. Tavr; 1University Hospitals Cleveland Medical Center, Cleveland, OH; 2University Hospitals Case Medical Center, Cleveland, OH; 3University Hospitals Cleveland Medical Center, Case Western Reserve University, University Heights, OH; 4N/A, Westlake, OH; 5N/A, Shaker Heights, OH; 6University Hospitals Cleveland Medical Center, Broadview Heights, OH; 7University Hospitals, Case Medical Center, Cleveland, OH

**Purpose:** Left-sided portal hypertension is an uncommon entity (accounting for less than 5% of all patients with portal hypertension). The most common cause is splenic vein thrombosis. However, the absence of splenic vein thrombosis constitutes an infrequent subset. The goal of this retrospective review was to evaluate the incidence, etiology, clinical presentation and outcomes of left-sided portal hypertension with esophageal varices and further stratify them into the presence or absence of splenic vein thrombosis.

**Materials:** A retrospective chart review of a single tertiary center from August 2005 to September 2017 found 16 patients (7 male and 9 female) with left-sided portal hypertension. The mean age of the patients was 63 years (22-87 years). Cross sectional imaging was reviewed to identify splenic vein thrombosis. Etiology, clinical presentation and management was reviewed for all patients.

**Results:** Five patients with left-sided portal hypertension showed no splenic vein thrombosis. Of these, 3 had lymphoproliferative disorders (ALL, multiple myeloma, and follicular lymphoma) and cryptogenic etiology. Furthermore, 2 out of 5 patients had massive upper gastrointestinal bleeding, managed endoscopically with banding and glue. On the other hand, eleven patients with left-sided portal hypertension showed splenic vein thrombosis. Of these, 2 were secondary to tumor compression of the splenic vein, 7 with chronic pancreatitis, 1 with acute pancreatitis, and 1 secondary to distal pancreatostomy. In addition, 5 out of these 11 patients had massive upper gastrointestinal bleeding (3 treated with splenic embolization, 1 with endoscopic glue and 1 with endoscopic banding). No patients in either group showed recurrent bleeding.

**Conclusions:** Left-sided portal hypertension is an uncommon entity which can occur in the presence or absence of splenic vein thrombosis. These are typically asymptomatic, however, can present with catastrophic upper gastrointestinal bleeding from ruptured varices. Multidisciplinary involvement is required for optimal management.

---

**Abstract No. 612**

**Outcomes of transjugular intrahepatic portosystemic shunt using 12-mm-diameter polytetrafluoroethylene-covered stents in cirrhotic patients with portal hypertension and refractory ascites**

A. Gunn, K. Mahmoud, S. Kim, S. Moawad, B. Heeke, N. Ertel, R. Oser, M. Massoud, S. Saddeki, A. Abdel Aal; 1University of Alabama at Birmingham, Birmingham, AL; 2University of Alabama at Birmingham (UAB), Birmingham, AL; 3University of Alabama Birmingham, Birmingham, AL

**Purpose:** The objective of this study is to evaluate the efficacy, complications and survival outcomes of transjugular intrahepatic portosystemic shunt (TIPS) creation performed by using a 12-mm-diameter polytetrafluoroethylene (PTFE)-covered stent in cirrhotic patients with portal hypertension and refractory ascites.

**Materials:** We retrospectively reviewed the medical records of 187 patients who underwent transjugular intrahepatic portosystemic shunt (TIPS) from January 2004 to January 2017, using 12-mm PTFE-covered stents (Viatorr; Gore) for refractory ascites. Patients’ demographics, comorbidities, need for paracentesis, Model for End-stage Liver Disease (MELD) score, incidence or worsening of hepatic encephalopathy (HE) and the need for TIPS revision were recorded. Survival outcomes were also calculated.

**Results:** The study included 115 (61.5%) males and 72 (38.5%) females with a mean age of 57.1 years (SD = 9.2 years). Cirrhosis was caused most commonly by alcohol, hepatitis C virus (HCV) and NASH in 31%, 30.5% and 29.9% of patients. The mean Charlson comorbidity Index was 3.9 (SD = 1.1). The portosystemic gradient significantly decreased from a mean of 15.79 to 4.98 after TIPS (p<0.0001). Ascites was resolved at 3, 6 and 12 months after TIPS in 59.5%, 69.8% and 81.7% of the patients respectively. Freedom from paracentesis at 12 months after TIPS was seen in 93.3% of the patients. MELD score increased significantly after TIPS from a mean of 13.2 to 16.9 (p<0.0001). Before TIPS, HE was seen in 6.5% of the patients. After TIPS, HE was seen in 38.2%, 50.4% and 55.3% at 3, 6 and 12 months respectively. Medically uncontrolled HE was seen in 17.5% of the patients at 12 months. TIPS revisions were performed in 8.0%, 11.2% and 12.8% of the patients at 3, 6 and 12 months.
following TIPS, respectively. The overall survival at 3, 6, 12 and 60 months was 79.2%, 73.5%, 66.3% and 46.5% respectively.

**Conclusions:** The 12 mm diameter PTFE-covered stent used for TIPS in cirrhotic patients with refractory ascites appears more efficacious and without increased complication rate compared to published literature on the 8 and 10 mm diameter similar stents. Survival outcomes also appear acceptable with 46.5% survival at 5 years.

---

**Abstract No. 613**

**Comparing patient radiation exposure in standard and intravascular ultrasound-guided transjugular intrahepatic portosystemic shunt (TIPS) creation procedures**

D. Kwak¹, R. Ramaswamy², M. Harrod², J. Duncan²;
¹University of Central Florida College of Medicine, Orlando, FL; ²Mallinckrodt Institute of Radiology at Washington University in Saint Louis, St. Louis, MO

**Purpose:** This study compares radiation exposure in standard and intravascular ultrasound-guided (IVUS) TIPS procedures.

**Materials:** Standard (N = 6) and IVUS TIPS procedures (N = 4) were analyzed via an audio-video procedure recording system synchronized to fluoroscopy imaging data. TIPS procedures were analyzed and divided into two phases: gaining portal vein access (PVA) followed by stent graft placement (SGP). The checkpoint separating these two phases was defined as the first instance when the guidewire was observed within the portal vein. For each phase, cumulative KAP, fluoroscopy time (FT), and phase time (PT) were compared.

**Results:** Cumulative KAP during PVA was higher in standard (55 ± 28Gy·cm², N = 6) vs IVUS procedures (9 ± 6Gy·cm², N = 4, p = 0.012). Wedged hepatic venography was determined to be an important contributor to total KAP for patients undergoing standard procedures (42 ± 12%, N = 5). Differences in cumulative KAP during SGP was not significant between standard (27 ± 16Gy·cm², N = 6) and IVUS procedures (15 ± 5Gy·cm², N = 4, p = 0.19).

**Conclusions:** IVUS-guided TIPS procedures can significantly reduce patient radiation exposure. The key driving factor was avoiding the need for wedged hepatic venography.

---

**Abstract No. 614**

**Comparison of efficacy of transjugular intrahepatic portosystemic shunt (TIPS) placement for refractory ascites versus hepatic hydrothorax**

S. Young¹, N. Rostambeigi², J. Bermudez³, J. Golzarian³; ¹University of Minnesota, Edina, MN; ²N/A, Columbia Heights, MN; ³University of Minnesota, Minneapolis, MN

**Purpose:** Transjugular intrahepatic portosystemic shunt (TIPS) placement is now most commonly utilized to treat refractory ascites. While fluid accumulation most typically occurs in the abdomen, it occasionally presents partially or primarily in the right pleural space. Given patients typically are less tolerant of fluid in the pleural space than the relatively larger anatomical space of the abdomen, the question of decreased clinical improvement following TIPS placement for pleural fluid has been raised. The goal of this retrospective study was to compare the clinical success rates of TIPS placed for hepatic hydrothorax with those for cirrhotic related ascites.

**Materials:** All patients who underwent TIPS placement between 1/1/2006 and 12/31/2016 were retrospectively reviewed. 147 patients had a TIPS placed for fluid accumulation, including 32 (21.8%) who had hepatic hydrothorax and 115 (78.2%) who had ascites. The average age was 56.1 years and the cohort consisted of 66% (n = 97) men and 34% (n = 50) women. Factors related to etiology of cirrhosis, reason for TIPS placement, frequency and volume of fluid removal as well as procedural factors, complications, and clinical outcomes were recorded. A propensity score matching analysis was performed to account for differences in baseline laboratory values, etiology of cirrhosis, age, and average number of thoracenteses or paracenteses performed per week.

**Results:** The frequency of clinical improvement was lower in the patients with fluid accumulation in the pleural space (62.5% (20/32)) than in those with accumulation in the abdomen (72.2% (83/115)) however, this was not statistically significant (p = 0.38). Propensity score matching was able to match 24 of the patients with hepatic hydrothorax with 46 of those with ascites. After propensity score matching the efficacy became more equivalent (pleural 58.3% (14/24) vs abdomen 63% (29/46); p = 0.8).

---

<table>
<thead>
<tr>
<th>IVUS Patient #</th>
<th>Age (yr)</th>
<th>PVA: FT (min)</th>
<th>PVA: KAP (Gy·cm²)</th>
<th>SGP: PT (min)</th>
<th>SGP: KAP (Gy·cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42</td>
<td>25</td>
<td>4.0</td>
<td>7</td>
<td>91</td>
</tr>
<tr>
<td>2</td>
<td>67</td>
<td>27</td>
<td>4.4</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>58</td>
<td>45</td>
<td>9.6</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>58</td>
<td>19</td>
<td>6.4</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Patient #</th>
<th>Age (yr)</th>
<th>PVA: FT (min)</th>
<th>PVA: KAP (Gy·cm²)</th>
<th>SGP: PT (min)</th>
<th>SGP: KAP (Gy·cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61</td>
<td>34</td>
<td>7.2</td>
<td>91</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>41</td>
<td>8.0</td>
<td>69</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>61</td>
<td>90</td>
<td>20.0</td>
<td>75</td>
<td>67</td>
</tr>
<tr>
<td>4</td>
<td>67</td>
<td>35</td>
<td>12.1</td>
<td>42</td>
<td>31</td>
</tr>
<tr>
<td>5</td>
<td>56</td>
<td>40</td>
<td>6.9</td>
<td>25</td>
<td>33</td>
</tr>
</tbody>
</table>

¹Wedged hepatic venography not employed.
Conclusions: TIPS placed for refractory hepatic hydrothorax is equally clinically efficacious as those placed for refractory ascites.

Abstract No. 615

Performance of MELD score versus MELD-Na in predicting 90-day survival after TIPS placement
N. Frenk1, Z. Irani1, K. Yamada1, S. Ganguli1, R. Chung2, D. Pratt2, A. Allegretti3; 1Division of Interventional Radiology, Department of Radiology, Massachusetts General Hospital, Boston, MA; 2Division of Hepatology, Department of Medicine, Massachusetts General Hospital, Boston, MA; 3Division of Nephrology, Department of Medicine, Massachusetts General Hospital, Boston, MA

Purpose: The Model for End-Stage Liver Disease (MELD) score was originally developed to assess prognosis after TIPS placement. The addition of sodium to the MELD score (MELD-Na) has been proposed as a more accurate prognostic score for overall survival. We assessed the performance of MELD vs. MELD-Na in predicting 90-day survival after TIPS placement.

Materials: Retrospective review of TIPS placements for ascites and hemorrhage at a major academic healthcare network between 1994 and 2014. MELD/MELD-Na scores were assessed for their ability to predict 90-day survival using area under the receiver operating curves (AuROC) and compared using change in AuROC, category free net reclassification index (NRI), and integrated discrimination improvement (IDI). Stratified analysis by TIPS indication was performed.

Results: Three hundred seventy seven TIPS placements were analyzed (225 for hemorrhage, 152 for ascites/hydrothorax). 90-day survival was 75% (282/377) for all subjects, 76% (170/225) for the hemorrhage subgroup, and 74% (112/150) for the ascites subgroup. For all subjects, median MELD score was 16 [IQR 11, 21] with AuROC of 0.77. Median MELD-Na was 19 [IQR 14, 23] with AuROC of 0.77. MELD and MELD-Na were highly correlated (r = 0.94; p < 0.001). MELD AuROC was 0.82 for the bleeding subgroup and 0.70 for the ascites subgroup. Addition of Na to the MELD score did not improve its performance by change in AuROC, NRI, or IDI for all patients or when stratified by TIPS indication, except for NRI in the bleeding subgroup (see Table).

Conclusions: MELD and MELD-Na performed similarly when predicting 90-day survival after TIPS. MELD-Na score performs better in TIPS placed for hemorrhage compared to TIPS placed for ascites. Further study is required to improve predictive scores in this population.

Abstract No. 616

Clinical and technical success of transjugular intrahepatic portosystemic shunt (TIPS) reduction via the parallel stent technique
L. Shreve1, E. Lee1, K. Fernandes1, J. McWilliams1, J. Moriarty1, S. Padia1, S. Kee2; 1Interventional Radiology, Department of Radiology, University of California Los Angeles, Los Angeles, CA

Purpose: To determine the clinical and technical outcomes of TIPS-R using the parallel stent technique.

Materials: Clinical data were retrospectively collected from 21 patients who underwent TIPS-R using parallel stent technique between 2011-2017. Data were compared from TIPS to TIPS-R, and TIPS-R to 1-year follow-up or death if sooner. West Haven (WH) scores were taken from clinical records, and the highest WH score was utilized. If no score was assigned, a score was determined in accordance with NEJM criteria. The frequency of hospitalization was recorded and normalized over the number of days within the time period.

Results: Twenty-one patients (7 F), age 62.0 ± 11.6 years, underwent TIPS-R secondary to RHE (n = 20) or ALF (n = 1). The most common underlying liver diagnoses were alcoholic liver disease (n = 4) and NASH (n = 4). The average time from TIPS to TIPS-R was 402 ± 382 days. At reduction, the average portosystemic gradient increased from 8.1 ± 4.6 to 12.1 ± 4.6 (p < 0.001). Of the 20 patients with RHE, 18 reported immediate clinical improvement in HE post-reduction and 11 had permanent improvement over the follow-up period. Three patients had recurrent HE requiring TIPS closure, 2 patients underwent liver transplant, and 4 had intermittent improvement. Average WH score was 3.4 ± 0.5 pre-reduction and 2.4 ± 1.3 post-reduction (p = 0.022). Frequency of hospitalization per days improved from 0.029 ± 0.027 pre-reduction to 0.011 ± 0.014 post-reduction (p = 0.014).

Conclusions: TIPS reduction via parallel stent technique is a technically and clinically effective procedure, as demonstrated by its capacity to significantly increase the portosystemic gradient, improve the clinical rating of HE, and reduce the frequency of HE-related hospitalizations.

Abstract No. 617

Technical predictors of initial transjugular intrahepatic portosystemic dysfunction
S. Majumdar1, O. Akinwande2, N. Mani2, D. Picus2, S. Kim2, M. Darcy2, R. Ramaswamy2; 1Washington University in St. Louis, St. Louis, MO; 2Mallinckrodt Institute of Radiology, St. Louis, MO

<table>
<thead>
<tr>
<th></th>
<th>All TIPS n = 377</th>
<th>Hemorrhage n = 225</th>
<th>Ascites n = 152</th>
</tr>
</thead>
<tbody>
<tr>
<td>MELD</td>
<td>AuROC 0.77</td>
<td>MELD-Na 0.77</td>
<td>MELD-Na 0.83</td>
</tr>
<tr>
<td></td>
<td>Category-free NRI 0.05</td>
<td>0.68</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>IDI 0.0004</td>
<td>0.53</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>P Value</td>
<td>P-value</td>
<td>P-value</td>
</tr>
<tr>
<td></td>
<td>0.62</td>
<td>0.51</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>0.82</td>
<td>0.70</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
</tr>
</tbody>
</table>


**Purpose:** To assess technical predictors of Transjugular Intrahepatic Portosystemic Shunt (TIPS) dysfunction.

**Materials:** A retrospective cohort analysis of 235 consecutive patients that underwent TIPS placement from Jan 2014-Feb 2017 was analyzed. Technical factors assessed included TIPS location (proximal and distal landing zone), operator experience, portal vein thrombosis, TIPS angle acuity, and stent length. TIPS angle was defined as the angle of stent entry into the portal vein and was measured by two independent radiologists blinded from the analysis. Proximal landing zone was defined by shunt origin in the inferior vena cava (IVC), right hepatic vein (RHV), middle hepatic vein (MHV), or left hepatic vein (LHV). Distal landing zone was categorized as right, left, or main portal vein (RPV, LPV, MPV). A multiple logistic regression model was used for analysis.

**Results:** Of 235 patients who had initial TIPS placement, 17.4% (41/235) underwent subsequent revision for TIPS dysfunction. TIPS dysfunction was due to stenosis at the hepatic venous end (24/41), mid-portion of the stent (2/41), portal venous end (6/41), complete thrombosis (6/41), and multifactorial in (3/41). Median follow-up was 27.1 mo. Average time after TIPS placement to TIPS dysfunction was 0.7 ± 5.0 mo. TIPS was most commonly placed in RHV extending to RPV (68.5%, 161/235), followed by MHV to RPV (11.9%, 28/235), with the rest originating in MHV or IVC and ending in MPV or LPV (19.5%, 46/235). Decreasing angle of entry into the portal vein was associated with greater likelihood of TIPS dysfunction (OR 0.926, 95%CI .904-.949, p<.001). Average TIPS angle for patients with TIPS dysfunction was 111.8 ± 19.1° compared to 136.5 ± 15.6° in those without dysfunction (p<.001). Stent length (p = .304), operator experience (p = .344), portal vein thrombosis (p = .388), proximal TIPS landing zone (p = .324), and distal TIPS landing zone (p = .167) were not predictors of TIPS dysfunction.

**Conclusions:** The angle of TIPS stent entry into the portal vein is a predictor of future TIPS dysfunction. Stent length, shunt location, operator experience, and portal vein thrombosis were not associated with TIPS dysfunction.

---

**Abstract No. 618**

Clinical efficacy of transjugular intrahepatic portosystemic shunt (TIPS) reduction for the treatment of post tips complications including encephalopathy, hepatic failure and heart failure: predicting the necessity of TIPS occlusion versus TIPS reduction

G. Hoots1, B. Zwiebel2, L. Rachakonda3, K. Kuppler3, R. Gnesda4; 1Florida Interventional Specialists, Tampa, FL; 2Radiology Assoc. of Tampa, Inc., Tampa, FL; 3University of South Florida, Tampa, FL

**Purpose:** To evaluate multiple indicators of hepatic function and degree of post TIPS shunting in predicting the need for TIPS occlusion over reduction in post TIPS patients with liver failure and encephalopathy.

**Materials:** 215 TIPS placements between June 2011 and August 2017. All were evaluated for followup interventions and respective indications. Pre- and postprocedure portal pressures, time from initial TIPS to subsequent intervention, serum ammonia, hepatic encephalopathy scores, and MELD score components were recorded. MELD and Na-MELD scores were calculated. These data were then compared between patients.

**Results:** 19 patients required TIPS reduction or occlusion for encephalopathy, pulmonary hypertension, hepatic failure, or heart failure. 3 TIPS reduction patients required occlusion due to encephalopathy. Of the 10 patients that had initial TIPS reduction, 6 had resolution of encephalopathy, 1 improved, and 3 patients had TIPS occlusion for persistent encephalopathy. Of the 9 patients that had TIPS occlusion without attempted TIPS reduction, 5 died, the 4 surviving patients demonstrated improvement. Of the three patients that had subsequent occlusion, one had improved encephalopathy but died of heart failure post MI on PPD #7, one had improvement and the other had unchanged encephalopathy. No statistically significant differences were found in preintervention variables, time from original TIPS, or portal pressures. All patients that had reduction only demonstrated resolution of hepatic encephalopathy and therefore did not have subsequent occlusion.

**Conclusions:** 55% mortality in the patients that had initial TIPS occlusion without attempted reduction could be attributed to hemodynamic changes or post TIPS hepatic vascular injury. Only 1 mortality was noted in the reduction group from post procedural myocardial infarction. Although no differences were found in multiple variables to predict success of initial TIPS reduction, there were trends in ammonia, MELD and Na-MELD which may show significance with a larger sample. Further study may be difficult given the rarity of post TIPS reduction/occlusion procedures.

---

**Abstract No. 619**

Percutaneous transhepatic obliteration of bleeding rectal varices utilizing sodium tetrade cycyl sulfate foam and interlocking detachable coils: a single-center experience

J. Gruener1, M. Cristescu1, D. Shilo1, A. Fischman1, R. Patel1, F. Nowakowski1, E. Kim1, V. Bishay1, M. Ranade1, R. Lookstein1; 1Icahn School of Medicine at Mount Sinai, New York, NY

**Purpose:** Bleeding rectal varices are a rare but serious complication in patients with cirrhosis and portal hypertension. While medical and endoscopic approaches may be favored at many institutions, percutaneous transhepatic obliteration can be a safe and effective option, and an excellent adjunct or alternative to TIPS for select patients. We report our obliteration technique and clinical outcomes.

**Materials:** This review was performed with institutional IRB approval. A retrospective review was performed of all cases at our institution from 2011 to 2017. A total of 5 transhepatic obliteration procedures were performed in 5 patients (3 male/2 female; mean age 60), 4 with active rectal variceal bleeding requiring transfusions and 1 with a history of recurrent rectal variceal bleeding episodes. MELD score was 0-10 in 3 patients, 11-20 in 1 patient, and >20 in 1 patient. In all patients, medical and endoscopic approaches, percutaneous transhepatic obliteration can be a safe and effective option, and an excellent adjunct or alternative to TIPS for select patients. We report our obliteration technique and clinical outcomes.

**Materials:** This review was performed with institutional IRB approval. A retrospective review was performed of all cases at our institution from 2011 to 2017. A total of 5 transhepatic obliteration procedures were performed in 5 patients (3 male/2 female; mean age 60), 4 with active rectal variceal bleeding requiring transfusions and 1 with a history of recurrent rectal variceal bleeding episodes. MELD score was 0-10 in 3 patients, 11-20 in 1 patient, and >20 in 1 patient. In all patients, medical and endoscopic approaches, percutaneous transhepatic obliteration can be a safe and effective option, and an excellent adjunct or alternative to TIPS for select patients. We report our obliteration technique and clinical outcomes.
therapies were attempted unsuccessfully prior to variceal obliteration. All cases were performed using sodium tetradecyl sulfate foam and interlocking detachable coils from a percutaneous transhepatic approach. One patient underwent TIPS prior to variceal obliteration.

**Results:** Immediate postprocedural technical success, defined as the lack of continued opacification of rectal varices on postprocedural angiography, was 100%. One patient developed a right flank hematoma and small volume hemoperitoneum discovered at paracentesis on postprocedure-day 2 which did not require intervention. One patient was lost to follow-up following discharge. Over a median clinical follow-up time of 1 month, no patients required repeat endoscopic or endovascular intervention. One patient reported bleeding requiring hospitalization and transfusion at 4 months following the procedure, which subsequently resolved spontaneously.

**Conclusions:** Percutaneous transhepatic obliteration is a safe and effective treatment for rectal varices related to cirrhosis and portal hypertension. Additional follow-up is needed to evaluate the longer-term efficacy for controlling and preventing bleeding.

---

**Abstract No. 620**

Incidence and pathophysiology of transjugular intrahepatic portosystemic shunt (TIPS) complicated with lower extremity edema

N. Rostambeigi, S. Young, P. Shrestha, M. Schooley, J. Golzarian; University of Minnesota, Minneapolis, MN

**Purpose:** TIPS is consistently proven to benefit patients with ascites, hydrothorax and gastrointestinal bleeding, however adverse events do occur after TIPS. Lower extremity edema (LEE), an under-reported complication of TIPS, can cause significant morbidity. This study aims to measure the incidence and pathophysiology of LEE after TIPS.

**Materials:** Between 2006-2016, a total of 220 patients underwent TIPS at our institution. LEE was defined as new onset or worsened edema up to one year after TIPS. Changes in diuretic use, clinical outcome of LEE, etiology of cirrhosis and effectiveness of TIPS in reducing ascites/hydrothorax were documented. Cardiac ventricular function was evaluated by echocardiography. Patients without close follow-up were excluded. Improvement in ascites was defined 25% fewer paracenteses.

**Results:** 205 patients were eligible for inclusion. 132 (64%) were male. Mean (SD) age was 54 (11) years old. Mean portosystemic shunt gradient changed from 18 to 7 mm Hg with mean (SD) post TIPS gradient of 7 (3). 80 (39%) patients had LEE at baseline. 101 patients (49%) had new onset or worsened LEE with median onset at one month follow-up. 62 out of 101 patients with LEE (61%) subsequently improved their edema (9 with conservative measures, 53 with diuretics). LEE was persistent despite diuretics in 36 patients (35%) at median follow-up of 21 months. Of note 30 out of 80 (37%) with baseline LEE had worsening edema. Multiple logistic regression analysis showed no significant impact from age, gender, ejection fraction, portosystemic gradient change and improvement in ascites on LEE. Presence of baseline edema prior to TIPS was protective in multivariate analysis (OR = -2.7, p = 0.007).

**Conclusions:** LEE can complicate TIPS in almost half of patients, independent of left ventricular function. Close clinical follow-up after TIPS, without initially changing diuretics is recommended. Baseline edema does not necessarily lead to worsening edema after TIPS. Further studies are needed to better clarify the pathophysiology of LEE after TIPS.

---

**Abstract No. 621**

Technical success and outcomes in adolescent patients following transjugular intrahepatic portosystemic shunt placement

A. Hage, J. Chick, J. Gemmete, N. Dasika, R. Srinivasa; University of Michigan, Ann Arbor, MI

**Purpose:** To report the technical success and clinical outcomes in patients undergoing transjugular intrahepatic portosystemic shunt (TIPS) placement less than 21 years of age.

**Materials:** 25 patients, including 14 (56%) males and 11 (44%) females, with mean age of 13.3 years (range, 2-20 years) underwent TIPS placement from 1997 to 2017. Indications, etiology of hepatic dysfunction, stent type, manometry, technical success, complications, and clinical outcomes were recorded.

**Results:** Indications for TIPS included: variceal bleeding (22; 88%) and refractory ascites (3; 12%). Etiology of liver disease included: portal or hepatic vein thrombosis (6; 24%), biliary atresia (5; 20%), cryptogenic cirrhosis (4; 16%), autosomal recessive polycystic kidney disease (3; 12%), primary sclerosing cholangitis (2; 8%), chronic total parenteral nutrition (1; 4%), complications secondary to chemotherapy (1; 4%), steatohepatitis (1; 4%), autoimmune hepatitis (1; 4%), and dyskeratosis congenita (1; 4%). Stents used included: Viatorr (12; 48%), Wallstent (9; 36%), Express (4; 16%), and iCast (1; 4%). Average pre-TIPS and post-TIPS portacaval gradient was 16.9 ± 2.0 and 6.6 ± 3.6, respectively. The gradient was reduced in 21 (84%) patients. TIPS placement was technically successful in 96% of cases with no immediate complications. TIPS revision was required in 11 (44%) patients, with an average of 2.1 revisions. Hepatic encephalopathy developed in 11 patients (44%), at an average of 221.5 days following TIPS placement. 6 (24%) patients received a liver transplant, and 1 patient died during the study period from complications from an epidural tumor.

**Conclusions:** TIPS placement in adolescents is a safe and viable procedure with high technical success rate and high survival rate. TIPS revision may be necessary.

---

**Abstract No. 622**

Utility of over-dilation of 10 mm TIPS stent with 12-mm balloon angioplasty

T. Lewis, A. Sarwar, J. Weinstein, M. Ahmed; Beth Israel Deaconess Medical Center, Boston, MA

**Purpose:** The role of balloon angioplasty of expanded TIPS stents remains controversial. The efficacy of this technique is difficult to study because of the small numbers of patients with TIPS stents requiring angioplasty. This study sought to determine the utility of balloon angioplasty of expanded TIPS stents.

**Materials:** A retrospective review of balloon angioplasty of expanded TIPS stents over a 6-year period was performed. A total of 12 patients underwent balloon angioplasty of expanded TIPS stents. The indications for balloon angioplasty included stent occlusion (10 patients), stent stenosis (2 patients), and stent migration (1 patient).

**Results:** Of the 12 patients who underwent balloon angioplasty of expanded TIPS stents, 11 patients (92%) had successful balloon angioplasty. One patient (8%) had unsuccessful balloon angioplasty due to stent occlusion. All patients who underwent balloon angioplasty of expanded TIPS stents had clinical improvement after the procedure. The average time to clinical improvement was 3 days (range, 1-7 days). The average duration of clinical improvement was 1 month (range, 1-3 months).

**Conclusions:** Balloon angioplasty of expanded TIPS stents is a safe and effective technique for treating stent occlusion, stent stenosis, and stent migration. Balloon angioplasty of expanded TIPS stents can result in clinical improvement within 3 days and lasts for at least 1 month.
**Purpose:** TIPS placement in patients with refractory ascites (RA) with portosystemic gradient (PSG) < 8 mm Hg and <12 mm Hg in patients with variceal bleeding (VB) is associated with better outcomes. If dilation of a 10-mm TIPS stent to 10 mm does not reduce the PSG below the threshold, over-dilation with a 12-mm balloon may further reduce PSG. This study evaluated the technical success and clinical outcomes of TIPS over-dilated to 12 mm was performed.

**Materials:** After IRB approval, all TIPS placed between 01/2003 and 12/2016 were retrospectively reviewed. Ten patients who underwent 10-mm covered TIPS placement with inadequate response to 10 mm balloons underwent subsequent 12-mm balloon dilation. TIPS were placed for VB (4), refractory ascites (5), and Budd Chiari (1). A control group of 10 patients with 10-mm TIPS placement and 10mm dilation alone, were matched for age, indication, and MELD score. PSG, laboratory results, complications, and outcomes were compared.

**Results:** TIPS creation was successful in all 12-mm (average age 53 y ± 8.1, 60% male) and 10-mm (average age 48 y ± 9.4, 80% male) balloon dilation patients. In the 12-mm cohort, pre-TIPS PSG averaged 16.1 mm Hg ± 2.5, which reduced to an average 6.3 mm Hg ± 2.3 after 12-mm balloon dilation. On AP fluoroscopic imaging, the diameter of the TIPS changed significantly from an average of 10.5 mm ± 1.3 after 10-mm balloon dilation to 12.3 mm ± 1.3 after 12-mm dilation (p<0.001). In the 12-mm dilation cohort, 3 of 10 cases required TIPS revision, in an average revision time of 18.3 months, whereas 2 of 10 required TIPS revision in the 10-mm dilation cohort, in an average revision time of 7 months (p = 0.54). In TIPS performed for RA, 4 of 5 patients had resolution of ascites in the 12-mm group versus 2 of 5 patients in the 10-mm group. In TIPS performed for VB, rebleeding occurred in none of the 12 mm patients and 1 of 4 in the 10-mm patients.

**Conclusions:** Dilation of 10-mm TIPS stents with a 12-mm balloon decreases the PSG beyond the change achieved with a 10-mm dilation with good technical success and clinical outcomes.

---

**Abstract No. 624**

**Technical and patient-related factors predicting TIPS thrombosis with stent grafts**

Y. Jahangiri, T. Kerrigan, D. Prosser, B. Khalsa, C. Shabrang, L. Campos, B. Addicott, R. Schenning, J. Kaufman, K. Farsad; Charles T. Dotter Department of Interventional Radiology, Oregon Health & Science University, Portland, OR

**Purpose:** To identify technical and patient related risk factors predicting subsequent TIPS thrombosis with stent grafts.

**Materials:** Patients undergoing TIPS creation using stent grafts between 2003 and 2016 were retrospectively reviewed (n = 328). 236 cases with available follow-up were included. Patient demographics, clinical status, liver function, procedural details, and follow-up data were analyzed. Early thrombosis was defined as shunt occlusion within 2 months after TIPS creation. Competing risk Cox regression models were used to evaluate predictors of shunt occlusion, with post-TIPS liver transplant as the competing factor. A separate model including interactions between time and exposure variables was assessed. Risk factors of early thrombosis were evaluated using logistic regression models. P < 0.05 was considered statistically significant.

**Results:** Primary and secondary patency rates were 88.6% and 98.3%, respectively. Median follow-up was 13.1 months. TIPS thrombosis occurred in 27 cases (11.4%) at a median of 6.7 months (1 day–74.1 mo). Early thrombosis occurred in 11 cases (4.7%), 25 patients (10.6%) had a liver transplant a median of 11.5 months after TIPS. In multivariate analysis, technical factors predicting TIPS thrombosis included extension of stents into the portal vein (SHR: 3.03, P = 0.030) and presence of hematologic disorders (OR: 13.49, P = 0.018).

**Conclusions:** Baseline clinical factors and technical factors predict both early and long-term TIPS malfunction with stent grafts. Better understanding of associated risk factors may enable potential prophylactic measures to optimize shunt patency.
Transjugular intrahepatic portosystemic improves outcomes in cirrhotic patients with variceal bleeding: a population-based analysis

A. Niekamp\(^1\), M. Khan\(^2\), T. Daileda\(^3\), J. Kuban\(^4\), S. Yevich\(^2\), E. Miller\(^2\), A. Tamr\(^2\), S. Gupta\(^2\), S. Sheth\(^3\), R. Sheth\(^2\); \(^1\)The University of Texas at Houston, Houston, TX; \(^2\)MD Anderson Cancer Center, Houston, TX; \(^3\)University of Texas McGovern School of Medicine, Houston, TX; \(^4\)UT/MD Anderson, Houston, TX

**Purpose:** Variceal bleeding is a substantial cause of morbidity and mortality in patients with cirrhosis. Transjugular intrahepatic portosystemic shunting (TIPS) has been shown to improve survival in clinical studies with strict inclusion criteria, but the influence of TIPS on outcomes in the general population is not known. The purpose of this study was to perform a population-level analysis of the impact of TIPS in cirrhotic patients with variceal bleeding.

**Materials:** Using administrative data from acute care hospitals in California (2005-2011) and Florida (2005-2014), patients with cirrhosis and variceal bleeding were identified. All hospital encounters for these patients were then evaluated for subsequent interventions, complications, and mortality. A propensity score matching algorithm was used to estimate the influence of TIPS on survival in this patient population.

**Results:** A total of 566,593 patients with cirrhosis were identified; 38,184 (6.7%) patients were noted to have at least one episode of variceal bleeding and comprised the study cohort. TIPS was performed in 3,658 (9.6%) of these patients. There was a significant difference in incidence of malignancy (0.4% vs 2.3%, \(P < 0.001\)), diabetes (42% vs 34.7%, \(P < 0.001\)), and hepatorenal syndrome (14.5% vs 12.5%, \(P < 0.001\)) between the TIPS and non-TIPS patients. Endoscopic interventions for esophageal varices were less commonly utilized in the TIPS patients versus non-TIPS patients (68% vs 71.3%, \(P < 0.001\)). Following a propensity score matching algorithm, TIPS patients were found to have improved survival, as measured from the time of initial presentation, compared to non-TIPS patients (12-month survival 88% vs 85%, \(P < 0.001\)). There was also a significant decrease in the frequency of blood product transfusions for TIPS patients following the procedure (mean 1.6 transfusions/month before, 0.1 transfusions/month after, \(P < 0.001\)).

**Conclusions:** TIPS is associated with improved outcomes in patients with cirrhosis complicated by variceal bleeding.

<table>
<thead>
<tr>
<th>Patients (N)</th>
<th>TIPS</th>
<th>No TIPS</th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (% female)</td>
<td>3658</td>
<td>34,526</td>
<td>0.5</td>
</tr>
<tr>
<td>Age (median in years)</td>
<td>55</td>
<td>55.71</td>
<td>(&lt; 0.001)</td>
</tr>
<tr>
<td>Comorbidities (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coagulopathy</td>
<td>82.4</td>
<td>71.4</td>
<td>(&lt; 0.001)</td>
</tr>
<tr>
<td>Obesity</td>
<td>20.3</td>
<td>13.6</td>
<td>(&lt; 0.001)</td>
</tr>
<tr>
<td>Renal failure</td>
<td>40.1</td>
<td>31.6</td>
<td>(&lt; 0.001)</td>
</tr>
<tr>
<td>CHF</td>
<td>18.0</td>
<td>14.4</td>
<td>(&lt; 0.001)</td>
</tr>
<tr>
<td>Hepatorenal syndrome</td>
<td>14.5</td>
<td>12.5</td>
<td>(&lt; 0.001)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>42</td>
<td>34.7</td>
<td>(&lt; 0.001)</td>
</tr>
<tr>
<td>History of malignancy (%)</td>
<td>0.4</td>
<td>2.3</td>
<td>(&lt; 0.001)</td>
</tr>
</tbody>
</table>

Feasibility of intrahepatic portosystemic shunt creation in vivo using a radiofrequency wire

K. Farsad\(^1\), G. Davies\(^2\), L. Wu\(^2\), C. Bermingham\(^2\), B. Uchida\(^3\), J. Kaufman\(^2\); \(^1\)Oregon Health and Science University, Portland, OR; \(^2\)Baylis Medical, Mississauga, Ontario; \(^3\)OHSU Dotter Interventional Institute, Portland, OR

**Purpose:** To test the feasibility of a commercially available radiofrequency (RF) wire instead of a needle for intrahepatic track formation in portosystemic shunt creation in swine.

**Materials:** Three adult swine were used. The RF wire was used in lieu of the needle with the Rosch-Uchida TIPS set. Portosystemic shunts were created from the hepatic vein to the portal vein and from the IVC to the portal vein. Intravascular ultrasound (IVUS) guidance was used to visualize the RF wire in the liver. After accessing the portal vein, the RF wire was used as the working wire for completion of the portosystemic shunt when possible. In one animal, the TIPS was occluded using thrombin and gelatin sponge, and the RF wire was used for recanalization. Livers were harvested to assess for injury.

**Results:** Intrahepatic portosystemic shunt creation was successfully performed using the RF wire from the hepatic vein to a branch of the portal vein and from the IVC to the main portal vein. Clear visualization of the wire through the parenchymal track was seen by IVUS. The wire tracked a straight course through the liver under RF energy application without deflection. No injury to hepatic arteries or bile ducts was observed. The RF wire could be used as the working wire to complete the shunt, though occasionally an angled catheter was used to redirect the wire into the main portal vein. No cautery along the wire track was grossly observed. No grounding pad injury or cardiac arrhythmia was documented. The RF wire could recanalize a thrombosed shunt without significant deflection, but could also penetrate the ePTFE coating of the stent graft.

**Conclusions:** Intrahepatic portosystemic shunt creation was safely and successfully performed using an RF wire instead of a needle for intrahepatic track formation in swine. This technique may prove helpful for TIPS creation in cirrhotic livers, or in challenging cases such as Budd-Chiari, by safely penetrating the liver without deflection. The RF wire may also aid recanalization of thrombosed TIPS. A clinical trial in humans is pending.

Proton pump inhibitors are associated with increased risk of hepatic encephalopathy after transjugular intrahepatic portosystemic shunt creation

D. Lewis\(^1\), P. Suhocki\(^2\), M. Hall\(^2\), T. Smith\(^2\), C. Kim\(^2\), J. Ronald\(^2\); \(^1\)Duke University Medical Center, Durham, NC; \(^2\)Duke University, Durham, NC

**Purpose:** Hepatic encephalopathy is the most common complication after transjugular intrahepatic portosystemic shunt (TIPS) creation. Although proton pump inhibitors (PPIs) are regarded as a class of medications with an excellent safety profile, recent data
suggests that in cirrhotic patients PPIs may be associated with an increased risk of hepatic encephalopathy (HE), perhaps by altering microbial flora in the gastrointestinal tract with resultant changes in metabolites in portal blood. The purpose of this study was to determine whether PPI usage was associated with an increased risk of HE exacerbations after TIPS.

**Materials:** In this single-institution retrospective study, 199 patients (58 females, mean age = 56) underwent TIPS creation between 1/1/2005 and 4/1/2012 for ascites or hydrothorax (129), variceal hemorrhage (61), or both (9). The medical record was reviewed to determine dates of postprocedure PPI usage and HE exacerbations, as defined by hospital admission for HE or escalation in outpatient medical management. Negative binomial regression was used to analyze the rate of HE exacerbations per person-day following TIPS.

**Results:** Among 105 patients on chronic PPI therapy from the time of TIPS until death, transplant, or loss to follow-up, 73 patients experienced 135 HE exacerbations in 56207 person-days. Among 51 patients never on PPIs after TIPS, 15 experienced 16 HE exacerbations in 19517 person-days, a significantly lower rate of HE exacerbations per person-day compared to PPI users ($p < 0.001$). In multivariate regression, older age ($p = 0.04$), higher pre-TIPS MELD ($p < 0.001$), and PPI usage ($p < 0.001$) were independent predictors of HE exacerbations. The remaining 43 patients had intermittent PPI usage after TIPS. This independent crossover sample experienced 48 HE exacerbations during 32387 days on PPIs and 25 HE exacerbations during 26836 days off PPIs, a non-significant trend toward increased risk while on PPIs ($p = 0.08$).

**Conclusions:** In this study PPI use was associated with more frequent HE exacerbations after TIPS creation. These results raise the possibility that discontinuation of non-essential PPIs may reduce the risk of HE following TIPS.

---

**Abstract No. 628**

**Percutaneous transhepatic balloon dilation of biliary anastomotic strictures following living donor liver transplant: review of 9-year experience**

D. Tse¹, K. Lee¹, V. Lau¹, Y. Ho¹, W. Tso¹, F. Chu¹; ¹Queen Mary Hospital, Hong Kong, Hong Kong

**Purpose:** Biliary anastomotic stricture (BAS) is a well-known complication of liver transplants (LT), particularly following living donor liver transplant (LDLT). This study aims to review our experience of percutaneous transhepatic balloon dilation (PTD) of BAS at a large regional LT center.

**Materials:** Retrospective review of all adult LDLT patients undergoing PTD of BAS between Jan 2008 and Sept 2017 was performed. Transplant details including type of biliary anastomosis (duct-to-duct (DD) vs hepatojjunostomy (HJ)), procedural details including number of dilation procedures and balloon sizes, were recorded, as well as clinical, biochemical and radiological follow-up. Treatment success was defined as absence of stricture on cholangiogram and successful removal of biliary drain following dilation. Recurrence was defined as symptomatic BAS following initial removal of biliary drain. Treatment success and recurrence rates were compared between HJ and DD groups using Fisher’s exact test.

**Results:** A total of 192 consecutive patients (60% men, mean age 60 years, range 30-71 years) were included. 17 patients with HJ underwent only PTD, 7 patients with DD anastomosis underwent initial PTD ± subsequent endoscopic balloon dilation. Treatment success was achieved in 21 patients (88%) after mean 3.3 dilation procedures (range, 1-9), and average treatment duration of 171 days (range, 42-647 days). In median 26 months (range, 2-103 months) of post-treatment follow-up, recurrence was seen in 4 patients (17%), with 3 patients requiring further PTD. 3 of 4 cases of recurrence occurred within 6 months of treatment, in patients who underwent a relatively short duration of treatment ($77$ days) and 2 or fewer dilation procedures. Treatment success and recurrence rates were not significantly different between HJ and DD groups ($P = 1.00$ for both). There were no major complications.

**Conclusions:** PTD is an effective and safe treatment for BAS following LDLT, for both HJ and DD types of biliary anastomosis. Recurrence may be seen in early posttreatment period and may be related to fewer dilations and shorter duration of treatment.

---

**Abstract No. 629**

**Does the anastomosis matter? Outcomes of transjugular liver biopsies in OLT patients with bicaual and piggyback hepatic vein anastomoses**

A. Price¹, D. Tran², Y. Kim³, R. Kerlan⁴, M. Kohi⁵, R. Kohlbrenner⁶, K. Koli³, E. Lehrman³, A. Taylor³, N. Fidelman⁷; ¹Department of Radiology and Biomedical Imaging, San Francisco, CA; ²N/A, San Francisco, CA; ³UCSF, San Francisco, CA; ⁴UCSF, Kentfield, CA; ⁵University of California, San Francisco, San Francisco, CA; ⁶Loma Linda University, Loma Linda, CA; "University of California San Francisco, San Francisco, CA

**Purpose:** Transjugular liver biopsies are routinely performed in liver transplant recipients. Surgeons use two different surgical techniques to connect donor and recipient hepatic venous drainage: piggyback and bi-caval anastomoses. The purpose of this study is to determine what impact these surgical techniques have on technical success, complication rate, and procedure duration of transjugular liver biopsies.

**Materials:** All patients with hepatic transplants undergoing transjugular liver biopsy between September 2009 and September 2017 were included in the study. Data on patient demographics, surgical hepatic vein anastomosis, number of transjugular biopsy passes, tissue adequacy, complications, and fluoroscopy time were recorded.

**Results:** A total of 192 consecutive patients (60% men, mean age 60 years) with liver transplants underwent 315 transjugular liver biopsies. A total of 165 biopsies were performed on 97 patients with bi-caval anastomoses, and 150 biopsies were performed on 95 patients with piggyback anastomoses. Technical success rate for biopsies performed in the setting of a bi-caval anastomosis was significantly higher than for patients with piggyback anastomoses (100% versus 96%, $p = 0.04$). Diagnostic sampling rate at pathology was similar for bi-caval and piggyback anastomoses (91% versus 90%, $p = 0.90$). Rates of major complications, most often hemorrhage, were similar for both bi-caval and piggyback groups (5% versus 6%, $p = 0.73$).
Fluoroscopy time was similar, averaging 12.7 and 13.7 minutes in patients with bi-caval and piggyback anastomoses, respectively (p = 0.63).

Conclusions: Performing transjugular liver biopsy is safe in patients with orthotopic liver transplant. There is a slightly diminished chance of successfully cannulating the hepatic vein in patients with piggyback versus bi-caval anastomosis, however complication rates and procedure duration are similar.

Cost and positioning of ultrasound and electrocardiogram-guided PICCs
E. Keller1, E. Aragona2, H. Molina3, J. Lee4, R. Salem4, S. Resnick4, H. Chrisman5, J. Collins4; 1Northwestern University, Feinberg School of Medicine, Chicago, IL; 2N/A, Chicago, IL; 3N/A, Harwood Heights, IL; 4Northwestern University, Chicago, IL; 5Northwestern University, Glencoe, IL

Purpose: To compare the accuracies and costs of peripherally inserted central catheter (PICC) placement using anatomical landmarks and an ultrasound and electrocardiogram (US/ECG)-guided system in inpatient and outpatient settings.

Materials: 468 PICC placements at a single institution were reviewed: 250 inpatient placements with anatomical landmarks (Group A), 150 outpatient placements with anatomical landmarks (Group B), and 68 outpatient placements with an US/ECG-guided system (Group C). Costs were estimated using 2012 Medicare reimbursement rates. Chi-squared tests with phi coefficients were used to compare rates of ideal positioning and repositioning. Ideal position was defined as in or between the lower third of the superior vena cava and upper right atrium. Analyses of variance were used to identify independent variables associated with higher costs.

Results: No significant differences were found between groups in terms of age or gender (p > 0.05). Ideal catheter tip position rates for groups A-C were 53.3%, 64.7%, and 87.1%, respectively (φ = 0.24, p = 0.3% or price reduction of $25.29 (inpatient)/$41.82 (outpatient) would necessary for the ECG-guided system to be cost effective. However, repositioning also required an additional 50 minutes staff time per case and delayed treatment ≥24 hours in 5.1% of the entire cohort.

Conclusions: US/ECG-guided PICC systems can significantly reduce tip malposition rates. They may be cost-effective if indirect costs are considered in patient groups with high repositioning rates.

New design for an implantable portal vein port catheter device in a porcine model
F. Ahmed1, D. Johnson2; 1University of Colorado, Denver, Denver, CO; 2University of Colorado Denver, Centennial, CO

Purpose: Central venous access is the standard of care for the delivery of parenteral nutrition although it is associated with hepatobiliary dysfunction. We sought to study the delivery of parenteral nutrition into the portal vein compared to central venous delivery. During our review, we found no catheter device designed for portal vein placement. The aim of this study is to evaluate the feasibility of a permanent implantable portal vein catheter.

Materials: We created a novel balloon retention port catheter designed to reside in the main portal vein. We arrived at our final design after several considerations. The catheter had to have a permanent design, a retention feature at the catheter tip, and the ability to safely and easily be placed in a minimally invasive manner. We tested the efficacy of the catheter in a porcine model.

Results: A total of four portal vein port catheters were successfully implanted in four different pigs. The catheters were appropriately positioned and functioning for up to four weeks. The primary cause for catheter failure during implantation was due to the size of the catheter, which was addressed by reducing the catheter size. The primary cause for catheter failure once implanted was from failure of the balloon retention device, which was addressed with the final device’s balloon size and characteristics.

Conclusions: This study demonstrated that our new design for a portal vein port catheter device is feasible and functional. It can be safely placed in a minimally invasive manner using ultrasound and fluoroscopic guidance.

A retrospective analysis of lidocaine with epinephrine versus lidocaine alone in the placement of chest ports: does the vasoconstrictive effect of epinephrine result in shorter procedure times?
K. Devulapalli1, A. McCurry2, H. Yu3, A. Isaacs3; 1University of North Carolina, Chapel Hill, NC; 2University of South Carolina School of Medicine, Columbia, SC

Purpose: The vasoconstrictive effect of epinephrine makes it a theoretically useful addition to lidocaine in the placement of chest ports. Recently, there has been a national shortage of lidocaine with epinephrine (LE) resulting in the routine use of lidocaine without epinephrine (L) for port placement. Based on anecdotal evidence, this has resulted in increased procedural bleeding and longer procedure times. The goal of the current study is to retrospectively compare chest port procedure times in patients receiving LE versus L.

Materials: A retrospective analysis of 139 patients undergoing chest port placement from January through July 2017 was performed. Patient demographics included gender, age and procedure indication. Technical variables included number of port lumens, port laterality, local anesthetic type, use of sharp versus blunt dissection and procedure time. Laboratory parameters included platelet and international normalized ratio. Primary outcome included mean procedure time in minutes. Secondary outcome included port removal secondary to infection and/or hematoma. Descriptive statistics in addition to student’s t-test for comparison of means was performed.
Results: 139 patients (33 men, 106 women, mean age 57.4 years) were analyzed. 77 (55.4%) patients had ports placed with LE; 62 (44.6%) with L. 3 ports (2.2%) were removed because of hematoma and/or infection. No significant difference in mean procedure time between the two groups (23.6 (SD 6.4) LE vs 25.1 (SD 10.4) L, P = 0.30) was observed. Among operators utilizing sharp dissection techniques, significant differences in mean procedure time were observed (19.2 (SD 4.3) LE vs 25.4 (SD 8.5) L, P = 0.02). No significant differences were observed in those operators utilizing blunt dissection techniques (24.5 (SD 6.4) LE vs 25.0 (SD 10.8) L, P = 0.74).

Conclusions: No significant differences in procedural time or procedural complications were observed in patients receiving LE compared to L. Operators utilizing sharp dissection techniques may benefit from the use of LE for local anesthesia.

Abstract No. 633

Trans-splenic access for porto-mesenteric interventions: single-center evaluation of safety and efficacy
A. Birney1, A. Fischman2, D. Assael3, R. Lookstein1, E. Kim4, F. Nowakowski4, M. Ranade1, V. Bishay5, R. Patel6; 1Mount Sinai Hospital, New York, NY; 2Icahn School of Medicine at Mount Sinai, New York, NY; 3N/A, New York, NY; 4Mount Sinai Medical Center, New York, NY; 5Icahn School of Medicine at Mount Sinai Hospital, New York, NY

Purpose: Treatment of complex portomesenteric pathology (PMP) often requires alternative access sites. This study evaluates the safety and efficacy of endovascular management of PMP via percutaneous trans-splenic access (TSA).

Materials: A database review of all TSA from 2010-2017 was performed. A total of 36 procedures were performed in 33 patients (18 female, mean age 45, range 2-72). Procedure indication, technical details, technical success (defined as successful access to splenic vein), procedural success, 30-day mortality and major and minor adverse events (AEs) were evaluated. TSA was achieved in all cases using ultrasound guidance and 20g Chiba needle. The splenic vein was accessed in an intrasplenic location. Contrast injection was used to confirm needle access. An .018” wire and Neff sheath was placed (Cook Medical). Depending on the planned intervention the access was then exchanged for the appropriate sized sheath ranging from 4F to 7F. The access tract was embolized using Gelfoam, coils, plugs or nBCA/lipiodol.

Results: Clinical indications included: access for TIPS placement or revision (n = 19), variceal embolization (n = 11), portal vein intervention (n = 8), splenic shunt creation (n = 2), and arterio-portal fistula embolization (n = 1). Sheath size included: 4F (n = 4), 5F (n = 3), 6F (n = 27), 7F (n = 2). Access site was embolized with Gelfoam (n = 30), coils (n = 2), Amplatzer plug (n = 2), nBCA/Lipiodol (n = 2). Technical success for TSA was 100%. 30-day mortality was 8.3% (n = 3), and was unrelated to access in all cases. Intra-procedural bleeding requiring embolization occurred in 8.3% (n = 3). Post procedure bleeding was seen in 27.7% (n = 10) cases; of these, 13.9% (n = 5) required transfusion. No cases required a secondary embolization procedure. Procedural success was 94.4% (n = 34).

Conclusions: Endovascular management of complicated PMP is a challenging task and TSA, although not without risk, is a feasible adjunct tool in the management of these patients.

Abstract No. 634

Efficacy of endovascular stenting for malignant versus nonmalignant caval obstruction
T. Han1, S. Bondarev1, E. Keller2, S. Resnick3; 1Chicago Medical School, Chicago, IL; 2Northwestern University, Feinberg School of Medicine, Chicago, IL; 3Northwestern University, Chicago, IL

Purpose: To assess factors associated with symptom resolution after endovascular stenting for superior or inferior vena cava syndrome.

Materials: Eighty-six consecutive vena cava stent placements in 82 patients (53 ± 14 years old) at a single institution were reviewed for patient demographics, comorbidities, and durability of stent patency (also evaluated were persistent/recurrent symptoms, stent occlusion, and need for repeat stenting). Logistic regression was used to identify independent factors associated with stent patency, and phi coefficients and analysis of variance were used to compare cases subdivided by lesion location (superior vena cava, inferior vena cava) and the presence or absence of malignancy.

Results: Clinical follow-up was available in 77/86 (90%) cases. Technical success with clinical failure (persistent symptoms) occurred in 40% of these cases with a median follow-up of 67 (interquartile range, 14-570) days and mortality rate of 63% during this period. Malignant obstructions had a significantly higher clinical failure rate of 54% compared to 15% for non-malignant obstructions (Φ = 0.34, p = 0.002). However, only metastatic disease was independently associated with clinical failure when controlling for demographics, other comorbidities, and differential follow-up: adjusted odds ratio (aOR) and 95% confidence interval of 8.27 (2.79–24.50).

Conclusions: Vena cava stenting effectively resolves symptoms without need for repeat interventions in 85% of non-malignant obstructions compared to only 46% of malignant obstructions. Patients should be counselled accordingly, and those with malignant obstructions may require closer follow-up to evaluate the need for reintervention and goals of care.

Abstract No. 635

Drug-eluting balloon angioplasty in the treatment of renal dialysis arteriovenous fistula stenosis
Z. Qamhawi1, G. Makris1, V. Vergani1, R. Ubero1; 1Department of Radiology, John Radcliffe Hospital, Oxford University Hospitals, Oxford, United Kingdom

Purpose: Stenosis is a common complication of renal dialysis arteriovenous (AV) fistulas, leading to poor maturation, thrombosis, and loss of haemodialysis access. [1] Recent studies propose the use of drug-eluting balloon (DEB) over standard balloon angioplasty (POBA) for AV fistula stenosis. [2] We report our
experience in terms of safety and efficacy of using DEB angioplasty for the treatment of AV fistula stenosis.

**Materials:** A retrospective study was conducted of 23 patients (14 male; mean age 72.3 ± 14.0) with 26 AV fistula stenoses that were treated with a Paclitaxel-eluting balloon. Four stenotic lesions were de novo, whereas the majority were re-stenosis following PBOA. Immediate post-angioplasty technical success and complications are reported. A crossover design analysis was used to assess the intervention-free period following DEB angioplasty compared to PBOA in patients with re-stenosis.

**Results:** Technical success was 100% in DEB treated stenoses. No immediate complications occurred. Thirteen (50%) DEB treated stenoses were intervention-free at analysis (mean follow-up 11.1 ± 5.1 months). Remaining DEB treated lesions were intervention-free for a mean duration of 6.1 ± 3.1 months. The proportion of DEB treated stenoses free from intervention was comparable to PBOA at three months (95% vs. 91%; p-value = n.s.) A significantly greater proportion of DEB treated lesions was intervention-free at six months (50% vs. 18%; p-value = 0.039) and nine months (53% vs. 18%; p-value = 0.031). A higher proportion of DEB treated lesions was intervention-free at 12 months (22% vs. 9%; p-value = n.s.).

**Conclusions:** Drug-eluting balloon angioplasty appears feasible and safe for the treatment of AV fistula stenosis and seems to be associated with a longer intervention-free period compared to standard angioplasty. Further prospective randomised trials are warranted.

---

**Abstract No. 636**

A large-bore uncovered metallic stent for the treatment of malignant superior vena cava syndrome

S. Noh1, W. Yang1, H. Chu1, H. Yoon1, J. Kim1, D. Gwon1; 1Asan Medical Center, Seoul, Republic of Korea

**Purpose:** To investigate the safety and efficacy of large-bore uncovered metallic stent placement in patients with malignant superior vena cava syndrome.

**Materials:** Between August 2015 and December 2016, 27 consecutive patients (24 men and 3 women; mean age, 64.3 years; range, 52-80 years) with malignant SVC syndrome were retrospectively reviewed. All patients were treated with a large-bore uncovered metallic stent (20-30 mm in diameter). The size of stent was chosen based on the diameter of 15-25% larger than the SVC.

**Results:** The mean diameter of SVC and brachiocephalic vein (BCV) were 18.3 mm and 14 mm, respectively. Stent placement was technically successful in all 27 patients. The mean diameter of the stent was 24 mm. Any overstretching or overdistension of SVC and BCV was not observed. There were no major complications. The pressure gradient, which was 18.9 ± 8.0 mm Hg before stent placement, dropped significantly to 4.3 ± 3.0 mm Hg after stent placement (p < 0.001). Of the 25 patients symptomatic prior to stent placement, 23 (92%) experienced complete symptomatic relief 1-6 days after stent placement. The median patient survival and stent patency time were 116 days (95% confidence interval [CI], 80-150 days) and 116 days (95% CI, 77-155 days), respectively. Three (11%) of the 27 patients presented with stent dysfunction due to tumor ingrowth (n = 1) and intrastent thrombosis (n = 2).

**Conclusions:** Large-bore uncovered metallic stent placement appeared to be a safe and effective method for treating malignant SVC syndrome.

---

**Abstract No. 637**

Stent-graft placement to treat central venous stenosis in hemodialysis patients: long-term results

W. Yang1, D. Gwon1, S. Noh1, H. Chu1, J. Kim1, H. Yoon1; 1Asan Medical Center, Seoul, Republic of Korea

**Purpose:** To evaluate the efficacy and long-term outcomes of stent-grafts in patients with symptomatic central venous stenosis (CVS).

**Materials:** From October 2008 and August 2016, 14 hemodialysis patients (mean age 65 years, range 51-81; 9 male, 5 female) with symptomatic CVS treated with stent-grafts were included in this study. In 6 of the 14 patients, stent-grafts were primarily placed for an alternative for BMSs to treat CVS that did not respond to PTA or early relapse within 3 months after PTA. The remaining 8 patients had stent-grafts secondarily for in-stent stenosis in previously placed BMSs. Study endpoints were rates of technical success, clinical success, complications, and primary stent-graft patency.

**Results:** All stent-grafts were successfully placed. During the mean follow-up period (1259 days, range; 132-2965 d), symptomatic stent-graft dysfunctions requiring reintervention were observed in 4 of 12 patients. The mean primary stent-graft patency was 2127 ± 332 days (95% Confidence Interval: CI: 1476-2777 d). The cumulative primary patency rates at 1, 2, 5, and 8 years after stent-graft placement were 91.7%, 81.5%, 61.1%, and 61.1%, respectively. The mean primary stent-graft patency rate [2571 days (95% CI: 1879-3262 d)] in the secondary placement group after PTA and BMS was superior to that [1292 days (95% CI: 703-1880 d)] in the primary placement group after PTA, although the log-rank test result was not statistically significant between the two groups (P = 0.205).

**Conclusions:** Stent-graft placement to treat CVS in hemodialysis patients is safe and effective, providing superior long-term patency.

---

**Abstract No. 638**

Automated quantitative measurements of disease severity in patients with May-Thurner syndrome

A. Reposar1, A. Eifler2, A. Hoogi3, V. Arendt4, D. Cohn4, D. Rubin5, L. Hofmann6; 1Stanford University Medical Center, Stanford, CA; 2Stanford University, San Francisco, CA; 3Stanford University, Stanford, CA; 4Stanford University School of Medicine, Stanford, CA; 5Stanford University, Richard M., Stanford, CA; 6Stanford University Medical Center, Palo Alto, CA

**Purpose:** Historically, disease severity in venous disease has been derived from patient surveys, which are inherently subjective and qualitative. The purpose of this study is to describe a novel automated segmentation technique used to quantitatively measure disease severity in patients with May-Thurner Syndrome (MTS) from CT venography studies.

**Materials:** We retrospectively identified 20 MTS patients (15 chronic DVT; 5 lymphedema) who underwent venous stenting
and analyzed these patients’ preprocedure and postprocedure CT venography studies using an automated segmentation technique. This technique works by separating the different layers of the leg (i.e. muscle, fat, bone, etc.) using Hounsfield units and deriving quantitative measures of disease severity from these partitions. The derived measurements include water percentage (a surrogate for edema), fat density, leg circumference, and skin thickness. The Wilcoxon signed rank test was employed in the statistical analysis of these data.

Results: When comparing the right and left legs of the same patient prior to stenting, the automated sequencing method found a significant difference in all measures of disease severity (P ≤ 0.01), with the left leg showing more severe disease. The differences in all of these variables disappeared in the postprocedural images (P = 0.07, 0.40, 0.47), except leg circumference (pre P = 7.6 × 10⁻³, post P = 0.004). This suggests that although edema decreases after stenting, adipo-genesis also occurs, leaving the leg enlarged. When comparing images of left legs before and after stenting, the automated segmentation imaging data showed no significant difference in fat density (P = 1), skin thickness (P = 1), and leg circumference (P = 1). However, there was a significant decrease in the percent of water in the leg (P = 0.04) on postprocedure imaging.

Conclusions: The water percentage variable showed a significant decrease on postprocedure vs. preprocedure imaging, suggesting a decrease in the amount of edema following stenting. This objective variable is measurable and simple to calculate, making it a promising candidate for a quantitative measure of disease severity in patients with MTS.

Abstract No. 639

Outcome of iliocaval stent-assisted reconstruction in patients with chronic obstruction of the inferior vena cava

A. Vance¹, A. Graif², C. Grilli², U. Nwosu³, M. Liao⁴, D. Agriantonis⁵, G. Kimbiris⁵, M. Garcia⁶, D. Leung⁴; ¹Christiana Care Health System, Philadelphia, PA; ²Christiana Care Health System, Wilmington, DE; ³Christiana Care, Wilmington, DE; ⁴Christiana Care Health System, Newark, DE; ⁵Western University, San Gabriel, CA; ⁶N/A, Newark, DE; ⁷N/A, Greenville, DE; ⁸Vascular & Interventional Associates of Delaware, Wilmington, DE

Purpose: To evaluate the outcome of iliocaval stent-assisted reconstruction in patients with chronic iliocaval obstruction with and without superimposed acute thrombosis.

Materials: A retrospective review was performed of consecutive patients undergoing iliocaval stenting for chronic obstructive lesions from 1/2009 to 7/2017. Patients with chronic obstructions of the iliofemoral veins without IVC involvement (including May-Thurner) were excluded. Adjunctive treatments included venoplasty, pharmacomechanical thrombectomy (PMT), and catheter-directed thrombolysis (CDT). Endpoints included technical success, clinical success, adverse events, and patency. Technical success was defined as successful recanalization and stenting. Clinical success was defined as resolution of symptoms or decrease in Villalta score of at least 5.

Results: Twenty-nine consecutive patients (18 male, mean age 47) were enrolled in the study. Technical success was 100%. Mean number of stents used per interventional session was 7.3. The majority of stents used in the IVC were Wallstents (Boston Scientific) while self-expanding nitinol stents were used exclusively in the iliac veins. Adjunctive PMT and CDT were performed in 14 and 20 patients, respectively. Eight patients underwent repeat procedures (range, 2-10) during the follow-up period for recurrence or extension of disease. The IVC obstruction was caused by an indwelling filter in 9 patients. Of those 9, 5 filters were removed prior to IVC stenting. 3 were recanalized by balloon venoplasty, and 1 was excluded by stenting. No major adverse events were recorded. Five patients were lost to follow-up with a mean follow-up of 26.1 months in the remaining patients. Clinical success was 95.8%. Primary and secondary patency was 68% and 95% at 12 months, 53% and 95% at 24 months, and 35% and 95% at 36 months, respectively.

Conclusions: Endovascular IVC and iliocaval vein stenting is a safe and effective method for the treatment of patients with chronic iliocaval veno-occlusive disease.

Abstract No. 640

Endovascular treatment of SVC syndrome secondary to fibrosing mediastinitis: a feasibility and safety analysis

S. Majumdar¹, R. Shoela², D. Kim², R. Ramaswamy², N. Mani³, A. Salter³, O. Akinwande⁴; ¹Washington University in St. Louis, St. Louis, MO; ²Mallinckrodt Institute of Radiology, St. Louis, MO; ³Mallinckrodt Institute of Radiology, Chesterfield, MO; ⁴Washington University School of Medicine, St. Louis, MO; ⁵Washington University School of Medicine in St. Louis, St. Louis, MO

Purpose: To assess the outcomes of endovascular management for Superior Vena Cava (SVC) syndrome secondary to fibrosing mediastinitis (FM).

Materials: Between January 2004 and December 2016, 10 consecutive patients with endovascularly managed SVC syndrome secondary to FM were identified in an institutional database. Venograms were performed to assess the severity and location of the lesion and allow measurement for stent selection. Standard stenting and angioplasty techniques were utilized to establish luminal patency. A variety of stents including WALLSTENT, Cordis SMART stent, Palmaz-Schatz stent, and EV3 stents were utilized in this cohort. The safety, feasibility, clinical success as well as the primary and secondary patency were evaluated. Kaplan-Meier survival analysis was used to determine median duration of stent patency. A log rank test was used to test differences in primary stent use.

Results: Our cohort was predominantly female (7/10) with an average age of 42.2 ± 18.2 years. Median duration of follow-up was 32.0 mo (range, 1.6-115.9). 7 patients had idiopathic disease with no clear identifiable cause, while 3 had prior diagnoses of histoplasmosis, a known precipitant for FM. The most common presenting symptoms were facial and upper extremity edema, chest pain, and dyspnea. All patients underwent venography demonstrating stenosis (8/10) or occlusion (2/10) at initial presentation. Stenting or angioplasty was technically successful in nine patients (90.0%). Eight of ten patients had primary stenting while one had vascular patency and symptom resolution with angioplasty alone. Median duration of primary patency was 31.3 months (95%CI: 5.9, 103). Six patients (54.5%) required secondary revision procedures. Median duration of secondary patency was 6.1 months, with 25% of revisions occurring by 4 months and 75% occurring by 20.9 months. All treated patients
(9/9) reported symptomatic relief at 1-month follow-up, establishing a clinical success rate of 100%. There were no 30-day adverse effects related to the procedure.

**Conclusions:** This study demonstrates that endovascular therapy is a safe and feasible approach for managing FM-related SVC syndrome.

---

**Abstract No. 641**

**Safety and efficacy of using telescoping CTO devices for complex chronic occlusions in SVC syndrome**

K. Zhang¹, B. McCabe², C. Ishak³, R. Ahuja⁴, P. Brady⁵, S. Doddakashi⁶; ¹Einstein Medical Center, Philadelphia, PA; ²N/A, Philadelphia, PA; ³BronxCare Health affil. Icahn School of Medicine Mt Siani, New York City, Scarsdale, NY; ⁴Albert Einstein Medical Center, North Wales, PA; ⁵Albert Einstein Medical Center, Philadelphia, PA; ⁶St. Luke’s Roosevelt Hospital Center, New York, NY

**Purpose:** Evaluate efficacy and safety of telescoping CTO devices for recanalizing chronic advanced central vein occlusion in SVC syndrome patients where previous attempts have failed.

**Materials:** Multicenter retrospective review of 12 patients from 2015-2017 were performed. All procedures were performed by a single operator and 8 patients have failed previous attempts to recanalization while 4 patients had extensive attempt in the same session using other techniques before using CTO devices. Any potential complications such as bleeding, infection, and stent migration were reviewed. All procedures were performed through right common femoral vein access using an 6 French 70cm Sheath whose tip was placed in the distal SVC. Recanalization was performed by using weighted tip 0.018 inch wire in conjunction with a 0.018 crossing catheter inside of a supporting catheter. Angled crossing and supporting catheter were used in 4 patients who had brachiocephalic occlusions. All patients underwent angioplasty and stenting of the occluded segment. 7 Patients required body-flossing 2nd access site from the internal jugular vein. Patients were seen 3 days after procedure to assess clinical outcome and potential complications. Average follow-up time is 102 days.

**Results:** During a period of 1.8 years, 12 patients (age range 52-76 years, mean age 58 years) were treated percutaneously for significant non-tumoral SVC syndrome. All recanalization attempts using CTO device were successful angiographically. All 12 patients had near complete resolution of swelling on 3 day follow-up as well as long-term follow-up averaging 103 days post op. Average procedure time was 54 minutes; average fluoroscopy time was 24 minutes. There were no bleeding complications, no infection, no stent migration, no inadvertent perforation into the arterial system. There were 2 patients had insignificant soft tissue extravasation/venous perforation with 0.018 wire.

**Conclusions:** Using telescoping CTO technique for difficult to treat chronic central venous occlusion is a safe and effective approach in patient with SVC syndrome with good clinical outcome. It also shortens procedure time compared to conventional techniques.

---

**Abstract No. 642**

**Does timing of radiation treatment affect endovascular stenting procedure parameters in the treatment of SVC syndrome?**

C. Ghazi¹, S. Peterson¹, D. Coldwell², L. Dinglasan²; ¹University of Louisville, Louisville, KY; ²University of Louisville, Prospect, KY

**Purpose:** To determine if procedural parameters of superior vena cava (SVC) stenting are affected by timing of radiation therapy (XRT) in the treatment of SVC syndrome.

**Materials:** A single-institution, retrospective review of SVC stent placements between January 2008 and September 2017 identified patients in whom an SVC stent was placed for malignancy and had documented radiation therapy. Patient medical records were reviewed for fluoroscopy time, radiation dose, procedure time, contrast dose, and change in percent luminal narrowing prior to and after stenting. These procedural parameters were compared between patients who had XRT prior to stenting and those who had XRT after stenting utilizing the Mann-Whitney-U test.

**Results:** Between January 2008 and September 2017, there were a total of 26 patients who had SVC stent placement, 24 of whom had stents placed for malignancy and had documented XRT. 11 of 24 patients were male, and 13 of 24 patients were female. Average age was 56. Of these patients, 17 of 24 had stents placed prior to XRT, 11 of whom had all documented procedural parameters being examined; similarly, 7 of 24 had stents placed after XRT, 6 of whom had all documented procedural parameters. Average fluoroscopy time for stent placement prior to XRT was 18.1 minutes versus 18.6 minutes for stent placement after XRT. average radiation dose for

---

**Table:**

<table>
<thead>
<tr>
<th>Types of Occlusion</th>
<th>#Pt</th>
<th>Types of Devices Used</th>
<th>Complications</th>
<th>Ave Follow-up Time (days)</th>
<th># Successful Outcome</th>
<th>Average Fluoroscopy Time (min)</th>
<th># Needed 2nd Body Flossing Access Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left brachial cephalic occlusion only</td>
<td>4</td>
<td>2 Angled Triforce 2 Angled Navicross+Quickcross</td>
<td>2 with insignificant soft tissue extravasation</td>
<td>84</td>
<td>4</td>
<td>42</td>
<td>4</td>
</tr>
<tr>
<td>SVC and left brachial cephalic occlusion</td>
<td>2</td>
<td>2 Angled Navicross+Quickcross</td>
<td>0</td>
<td>133</td>
<td>2</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>SVC occlusion only</td>
<td>6</td>
<td>4 Angled Triforce. 2 Angled Navicross+Quickcross</td>
<td>3 with insignificant soft tissue extravasation</td>
<td>106</td>
<td>6</td>
<td>13</td>
<td>2</td>
</tr>
</tbody>
</table>
stent placement prior to XRT was 368.3 mGy and 237.4 mGy after; average procedure time for stent placement prior to XRT was 73.2 minutes and 94.8 minutes after; and average change in percent luminal narrowing was 39.6% for stent placement prior to XRT and 44.5% after. Mann-Whitney-U tests did not reveal statistically significant differences in any procedural parameter between groups.

Conclusions: Timing of radiation therapy relative to SVC stenting does not affect procedural parameters related to stent placement, suggesting radiation therapy prior to SVC stent placement does not result in a more complicated stenting procedure.

Abstract No. 643

Balloon-occluded retrograde transvenous obliteration from pericardial vein to eradicate gastric varices
Y. Kako1, K. Kobayashi1, J. Taniguchi1, H. Takaki2, K. Yamakado3; 1Hyogo college of medicine, Hyogo, Japan; 2Department of Radiology, Hyogo Medical Collage, Nishinomiya-Shi, Hyogo; 3Mie University School of Medicine, Tsu, Mie, Japan

Purpose: To elucidate the clinical meaning of performing balloon-occluded retrograde transvenous obliteration (BRTO) from pericardial vein (PCV) when it is the main drainage vein of gastric varices.

Materials: The frequency of PCV drainage, characteristics of patients with PCV drainage, technical and clinical success rates of BRTO from PCV were retrospectively evaluated in 272 patients who underwent BRTO for the treatment of gastric varices from 1998 to 2017 at our hospital. After catheterization of PCV, ethanalamine oleate (EO) was injected from the PCV under balloon occlusion.

Results: The main drainage vein of gastric varices was gastrorenal shunt in 258 patients (94.9%, 258/272), inferior phrenic vein in 9 patients (3.3%, 9/272), and PCV in 5 patients (1.8%, 5/272). Patients with PCV drainage consisted of 2 males and 3 females with a median age of 68.0 years (range, 39–71 years). There were no characteristic backgrounds in terms of liver function and cause of liver cirrhosis in these patients. BRTO was technically successful in 3 patients (60%, 3/5), but unsuccessful in the other 2 patients who received BRTO in an early period. The PCV was too narrow to catheterize in a patient, and the PCV was anastomosed to the left pulmonary vein that may cause severe complications by injecting EO in another patient. Gastric varices were completely eradicated in 2 patients (40%, 2/5), and shrunk in a patient (20%, 1/5).

Conclusions: Although the frequency PCV drainage of gastric varices is rare, it is important to know this root in order to improve clinical results of BRTO.

New York Presbytarian Hospital, New York, NY; 2GE Healthcare, New York, NY

Purpose: Deep vein thrombosis (DVT) recanalization cases can be time intensive, often requiring extensive fluoroscopic evaluation, contrast use, and repeat interventions. Contrast based road-mapping for device navigation is highly variable in delineating boundaries of chronically occluded vein segments. Improving operator confidence in catheter guidance through vascular occlusions is therefore invaluable in minimizing procedural time and radiation exposure. Pre-procedural diagnostic information is typically acquired prior to DVT recanalization (cross-sectional CT/MR venography). The purpose of this study is to evaluate the feasibility of utilizing center lines from preoperative imaging during traversal of DVT occlusions and overlay of data with real-time fluoroscopy (Vessel ASSIST, GE Healthcare).

Materials: Following institutional IRB application, clinical and imaging parameters from patients were reviewed (6 with ileocaval stenosis/occlusive DVT). Dedicated IR clinic consultations were performed (ileocaval patients CEAP scores >C2). All patients underwent preprocedural CT/MR venography prior to interventions. Vessel mapping to direct catheter navigation was utilized in all cases. Center line of occluded vessels were mapped prior to cases and registered to the patient using landmarks such as pelvic bones (with CT) or femoral heads (with MR) to assist with catheter navigation through occluded veins. Procedures were performed on the GE Discovery IGS 740 hybrid fluoroscopy system.

Results: All ileocaval vein catherizations performed utilizing vessel center line 3D overlay were successful. No procedural complications related to utilization of software for catheter navigation. Significant ease of comfort navigating vasculature comparable to use of contrast-based roadmaps was reported. No errors or difficulty in overlay setup reported by IR technologists.

Conclusions: 3D overlay with vessel tracking from preprocedural cross-sectional imaging data for ileocaval catheter navigation is technically feasible, noting decreases in contrast use compared to conventional venography. While our data supports continued use of this technology, further prospective evaluation of this roadmapping technique is warranted.

Abstract No. 645

Preoperative percutaneous transhepatic portal vein embolization in biliary malignancy: hepatic hypertrophy and posthepatectomy liver failure
D. Hyun1, J. Yim1, S. Cho1, K. Park2, H. Park1, S. Shin1, D. Choi1, S. Kim1, S. Lee2; 1Samsung Medical Center, Seoul, Seoul; 2Samsung Medical Center, Sungkyunkwan University School, Seoul, Republic of Korea; 3Kyungpook National University Hospital, Daegu, Republic of Korea

Purpose: To retrospectively investigate the change in future remnant liver volume (VFRL) after percutaneous transhepatic portal vein embolization (PTPE) and incidence of posthepatectomy liver failure (PHLF) according to serum bilirubin level in primary biliary malignancy.

Materials: Eighty-seven patients (62 men and 25 women, mean age; 66.9 years) who underwent PTPE before major hepatectomy between January 2004 and June 2016 were included and divided
into a jaundice group and control group for subgroup analysis. Liver volume was semi-automatically measured from CT data before and 18.5 days, on average, after PTPE in each patient. Correlation between VFRL change (degree of hypertrophy [DH], and percent increase in future remnant liver [%FRLinc.]) and serum bilirubin level at PTPE (TBPTPE) were analyzed. VFRL change and the incidence of PHLF were compared between groups. Univariate and multivariate regression were used for analyses.

**Results:** Mean VFRL before and after PTPE was 529.1 cm³ (range, 235.5 – 920.7) and 640.5 cm³ (range, 356.9 – 1322.2), respectively. DH and %FRLinc were 7.65 ± 4.22 (mean ± standard deviation) and 21.77 ± 13.34, respectively. There was no significant correlation between VFRL and TBPTPE was demonstrated (p>0.5). VFRL change was not significantly different between the two groups. Major hepatectomy was performed in 73 patients (83.9%). PHLF occurred in 6 patients (8.2%, two in jaundice and four in control group) and the incidence was not significantly different between the groups. Three patients in the control group died of PHLF.

**Conclusions:** High TBPTPE (≥ 3 mg/dL) seems to have no effect on VFRL change following PTPE and the incidence of PHLF is not likely to be different between the two groups.

---

### Abstract No. 646

**Peri-interventional use of Capturex filter catheter during removal of thrombosed inferior vena cava filters and venous thrombectomy: preliminary results of a single-institution experience**

A. Alharbi¹, M. Arabi¹, E. Dulaigan¹, S. Qazi¹, A. Alvi¹, M. Al-Moaiqel¹; ¹King Abdulaziz Medical City, Riyadh, Saudi Arabia

**Purpose:** Assess the effectiveness of the peri-interventional filter catheter (Capturex) in preventing symptomatic pulmonary embolism during removal of thrombosed inferior vena cava filters or thrombectomy of lower extremity deep venous thrombosis.

**Materials:** This retrospective study includes all consecutive patients who required peri-interventional use of Capturex filter catheter between January 2015 and July 2017. The study included 9 patients (6 males) with mean age of 45 years (16-100 years). Four cases had entrapped thrombus within the IVC filter (25-100% of the filter cone); four cases had filter related ilio caval thrombosis and one patient had isolated acute thrombosis of the left iliac veins. The thrombosed filter types included Denali (n = 4) and Optease (n = 4) with mean dwelling time of 31 days (8-61 days). The capturex device was deployed in the supra renal IVC prior to removal of the filter or initiation of thrombectomy. Adjunct thrombectomy was done with 10 Fr Aspirex catheter (n = 3), Cleane (n = 4), balloon maceration (n = 3) and 1 case with aspiration catheter.

**Results:** All 8 IVC filters were successfully removed and the iliac DVT patient was managed with no subsequent symptomatic pulmonary embolism at 30 days of follow-up. The Capturex device showed retained fragments of thrombus of variable sizes on venography before retrieval in all cases. However, the device was successfully retrieved without additional thrombectomy.

**Conclusions:** Capturex peri-interventional filter catheter may offer a safe and effective protection device during removal of thrombosed IVC filters or during mechanical thrombectomy. Further evaluation in a larger cohort remains warranted.

---

### Abstract No. 647

**Denali, Tulip, and Option inferior vena cava filter retrieval: a single-center experience**

R. Ramaswamy¹, H. Raman², E. Jun¹, N. Mani¹, S. Kim¹, O. Akimwande¹, Mallinckrodt Institute of Radiology, St. Louis, MO; ²Washington University School of Medicine, St. Louis, MO

**Purpose:** Compare the technical success and ease of filter retrieval in Denali, Tulip, and Option/Option elite inferior vena cava filters.

**Materials:** A retrospective comparative, institutional review board-approved study of Denali, Gunther Tulip, and Option/Option Elite IVC filters was conducted over a 49-month period at a single institution. Retrieval failure rates, fluoroscopy time, sedation time, use of advanced retrieval techniques, and filter related complications that led to filter retrieval failure were recorded. Analysis was performed using a logistic regression model, analysis of variance (ANOVA) or Kruskal-Wallis test. Adjustment for multiple pairwise comparisons used a Tukey post-hoc adjustment or Dwass, Steel, Critchlow-Fligner method.

**Results:** There were 107 Denali, 43 Option, and 39 Tulip filters deployed and removed. With an average dwell time of 93.5 days, 86.0 days, and 131 days, respectively which was significantly different however controlled for in the analysis. Retrieval failure rates were 0.9% for Denali, 11.6% for Option, and 5.1% for Tulip filters (Denali vs. Option, p = .018; Denali vs. Tulip p = .159; Tulip vs. Option, p = .045). Retrieval failure was due to or in combination of the following factors: filter hook embedment, filter tilt, or caval wall penetration. Median fluoroscopy time for filter retrieval was 3.2 minutes for the Denali filter, 6.75 minutes for the Option filter, and 4.95 minutes for the Tulip filter (Denali vs. Option, p < .01; Denali vs. Tulip, p < .01; Tulip vs. Option, p = .67). Advanced retrieval techniques were used in 0.9% of Denali filters, 21.1% in Option filters, and 10.8% in Tulip filters (Denali vs. Option, p < .01; Denali vs. Tulip, p < .01; Tulip vs. Option, p < .01).

**Conclusions:** The findings of this study indicate that there is higher technical success and easier retrieval of the Denali when compared to the Tulip and Option filter. Retrieval of the Denali filter required less fluoroscopy time and use of advanced retrieval techniques compared to both the Option and Tulip filters.

---

### Abstract No. 648

**Laser sheath–assisted removal of inferior vena cava filters with long dwelling time: a single-institution experience**

M. Arabi¹, A. Alharbi¹, S. Qazi¹, M. Al-Moaiqel¹; ¹King Abdulaziz Medical City, Riyadh, Saudi Arabia

**Purpose:** To evaluate the feasibility and safety of laser sheath assisted removal of IVC filters with long dwelling times after failed retrieval with standard techniques or in otherwise considered non-retrievable filters.

**Materials:** Between December 2015 and May 2017, seven patients underwent laser sheath assisted filter retrieval. Filters were Optease (n = 5), Recovery (n = 1) in infra renal position and 1 Optease in intra hepatic IVC. The mean dwelling time was 695 days (210-2111 days). Four patients had failed previous retrieval attempts using standard techniques, and were prescribed life-long prophylactic anticoagulation therapy. Glidestyle laser sheath was
used (12, 14 or 16 Fr) to disengage the filter from the IVC wall. The sheath was operated at 60 mJoule/mm with pulse repetition rate between 60-80 Hz. Two filters were removed via Jugular access and 5 were removed from femoral access.

Results: Laser sheath assisted filter removal was technically successful in all patients. The mean fluoroscopy time was 42 minutes (4-118 minutes) and the mean total dose area product (DAP) was 100477 mGy•cm². Four patients had IVC stenosis following retrieval and responded adequately to balloon dilatation. One patient had limited extravasation that required no intervention. No major complications were encountered. Patients were prescribed prophylactic enoxaparin for 10 days post procedure. Follow up imaging was available in 5 patients, which showed patent IVC with no stenosis or thrombosis. All patients discontinued the pre-procedure anticoagulation therapy.

Conclusions: Laser sheath assisted filter removal of IVC filters with long dwelling time is feasible after failed retrieval with standard techniques or in otherwise considered non-retrievable. Safety of this technique is yet to be proven in a larger patient cohort.

Abstract No. 560

Suprarenal inferior vena cava filter retrieval: a single-center 10-year experience
J. Mandel1, P. Shukla1, V. Bishay1, M. Ranade1, E. Kim1, F. Nowakowski1, R. Patel1, R. Lookstein1, A. Fischman1; 1Mount Sinai Hospital, New York, NY

Purpose: To evaluate the safety and efficacy of retrieval for inferior vena cava filters (IVCFs) placed in a suprarenal position.

Materials: Transjugular retrieval of IVCFs placed in a suprarenal position was performed in thirteen patients (5 men, 8 women; mean age: 45.1 ± 13.8 years) between July 2006 and July 2017 using a standard loop-snare technique. Patient charts were reviewed for patient demographics and procedural information. Descriptive analysis was performed using Microsoft Excel.

Results: Indications for IVCF placement, positioning, and retrieval are noted in Table 1. IVCFs retrieved included Option Elite (Argon Medical Devices, Inc., Athens, TX) (n = 9, 69%) and Günther Tulip (Cook Medical Inc., Bloomington, IN) (n = 4, 31%). Pulmonary embolism was suspected and ruled out in three patients (23%) during the indwelling period. Follow-up serum creatinine was available for 7 patients (54%), none of whom developed acute renal failure. Eleven suprarenal IVCFs (84%) were successfully retrieved after a median indwelling time of 1.8 months (range, 0.03-12.1). Retrieval was unsuccessful in 2 patients with Option Elite filters, one in whom the filter hook could not be snared (placed 2.5 months prior), and one with IVC wall implantation (placed 11.6 months prior). Thrombosis was not detected in any patients on preretrieval cavogram. There were no peri-procedural complications.

Conclusions: In the setting of VTE with contraindications to infrarenal IVCF deployment, temporary placement and endovascular retrieval of IVCFs placed in a suprarenal position is safe and feasible.

Table 1. Indications for Placement, Position, and Retrieval

<table>
<thead>
<tr>
<th>Indication for Placement (N %)</th>
<th>3 (23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augment AC</td>
<td>3 (23)</td>
</tr>
<tr>
<td>Preoperative</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Contraindication to AC</td>
<td>2 (15)</td>
</tr>
<tr>
<td>VTE + pregnancy</td>
<td>2 (15)</td>
</tr>
<tr>
<td>VTE lysis prophylaxis</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Failure of AC</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indication for Suprarenal Position (N %)</th>
<th>4 (31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrarenal IVC thrombosis</td>
<td>3 (23)</td>
</tr>
<tr>
<td>Renal vein thrombosis</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Gonadal vein thrombosis</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Prior infrarenal IVCF thrombosis</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Nonthrombotic infrarenal IVC narrowing</td>
<td>1 (8)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indication for Retrieval (N %)</th>
<th>11 (84)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Preoperative</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Repositioning</td>
<td>1 (8)</td>
</tr>
</tbody>
</table>

AC, anticoagulation; IVC, inferior vena cava; IVCF, inferior vena cava filter; VTE, venous thromboembolism.

Abstract No. 649

Percutaneous removal of the 24-French stainless steel greenfield filter: retrieval techniques and prospective outcomes
L. Chan1, W. Kuo1; 1Stanford University Medical Center, Stanford, CA

Purpose: Since FDA approval in 1973 as a permanent IVC filter, the 24-Fr Stainless Steel Greenfield was replaced decades ago and is now rarely encountered. Therefore, removal after prolonged dwell times has yet to be studied. We report our experience with attempted percutaneous retrieval of the 24-Fr Greenfield filter.

Materials: Over 5 years, 5 patients presenting with an embedded filter cone diameters including trapped calcified clot. A wire loop technique was operated at 60 mjoule/mm with pulse repetition of this technique is yet to be proven in a larger patient cohort.

Table 1. Indications for Placement, Position, and Retrieval

<table>
<thead>
<tr>
<th>Indication for Placement (N %)</th>
<th>3 (23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augment AC</td>
<td>3 (23)</td>
</tr>
<tr>
<td>Preoperative</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Contraindication to AC</td>
<td>2 (15)</td>
</tr>
<tr>
<td>VTE + pregnancy</td>
<td>2 (15)</td>
</tr>
<tr>
<td>VTE lysis prophylaxis</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Failure of AC</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indication for Suprarenal Position (N %)</th>
<th>4 (31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrarenal IVC thrombosis</td>
<td>3 (23)</td>
</tr>
<tr>
<td>Renal vein thrombosis</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Gonadal vein thrombosis</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Prior infrarenal IVCF thrombosis</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Nonthrombotic infrarenal IVC narrowing</td>
<td>1 (8)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indication for Retrieval (N %)</th>
<th>11 (84)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Preoperative</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Repositioning</td>
<td>1 (8)</td>
</tr>
</tbody>
</table>

AC, anticoagulation; IVC, inferior vena cava; IVCF, inferior vena cava filter; VTE, venous thromboembolism.
Abstract No. 651

Identifying
R. Dunlap¹, A. Demmert², A. Kieger³, C. Bishop⁴, B. Holly⁵; Johns Hopkins Hospital, Baltimore, MD; ²Johns Hopkins, Baltimore, MD; ³Johns Hopkins University Hospital, Baltimore, MD; ⁴Johns Hopkins Applied Physics Lab, Baltimore, MD; ⁵Johns Hopkins Hospital, Baltimore, MD

Purpose: Recent FDA safety communications have reiterated the importance of follow-up for patients with inferior vena cava (IVC) filters and removing the filters when they are no longer indicated. IVC filter retrieval rates vary widely, but overall remain low due to a variety of factors. Many of these patients are simply, “lost to follow-up.” This study evaluates an automated tool to identify patients with IVC filters who present to the emergency department (ED).

Materials: IRB approval was not required as the project was utilized for quality improvement. A near real-time analytics package was developed to apply natural language processing to radiology reports of all patients presenting to the ED. This package analyzes final radiology reports every 30 minutes to identify any mention of an IVC filter. The package then generates alerts which are sent to a secure cloud based dashboard for review by radiology staff.

Results: Over the initial 6-month period, our system generated a total of 72 alerts, of which 70 represented valid cases of deployed IVC filters for 60 unique patients. The system detected 2.8 patients per week or 12 per month. Further chart review revealed 39/70 (56%) patients did not have indications for permanent filtration and should consider filter retrieval, 13/70 (19%) patients had some mention of a filter complication in the radiology report, and 58/70 (83%) filters were placed at another medical center. Additionally, 29/70 (41%) filters were not mentioned in the radiology report final impression and 54/70 (77%) filters were not mentioned in the ED note assessment and plan.

Conclusions: Application of an automated analytic system led to the identification of a substantial number of patients with filters eligible for retrieval. The presence of an IVC filter in these patients was not routinely included in the final impression of the radiology reports or mentioned in the ED provider notes, indicating a subset of patients at risk for continued loss of follow-up.

Abstract No. 652

An image-based evaluation of IVC filter implant healing in a swine model: implications for performance and retrievability
J. Karanian¹, E. Jones¹, I. Bakhutashvili¹, R. Guidry¹, J. Esparza-Trujillo¹, R. Seifabadi¹, V. Krishnasamy², W. Pritchard¹, B. Wood³; ¹National Institutes of Health, Bethesda, MD; ²National Institutes of Health, Arlington, VA; ³National Institutes of Health, North Bethesda, MD

Purpose: To define the imaging characteristics and healing of IVC filters implanted in a swine model

Materials: Under fluoroscopic guidance, 7 Günther Tulip Vena Cava Filters (Cook Medical) were placed in the infrarenal IVC of 4 swine, 2 each in 3 swine. After 30 day implant duration, contrast-enhanced MDCT was performed. Retrieval of the more proximal filter was attempted by automated advance of a sheath over the retrieval snare catheter while measuring applied force followed by manual attempt if unsuccessful. Following euthanasia, the IVC was resected en bloc and microCT performed with 3 micron resolution. Filter interaction with the IVC wall was graded blindly following Oh et al. (Radiology 2011: 22-70-74) using MDCT imaging. Results were compared to microCT and histopathology.

Results: Of the 28 tines, the distribution among grades 0, 1, 2, 3 or indeterminate (grade 1-3) was 0%, 4%, 4%, 68% and 25% respectively. For the grade 3, the tines were in contact with muscle (44%), bowel (22%), aorta (11%), bladder (11%), ureter (6%) or lymph node (6%). MicroCT imaging allowed visualization of the IVC wall and identification of IVC filter penetration vs. deflection of the wall by the tine with it contained within the IVC. For example, in one specimen grading based on microCT clearly identified the IVC wall with a reclassification of the grade for 3 of 4 tines, as the vein wall can be discerned allowing discrimination between tenting and penetration of the IVC wall. None of the four filter retrieval attempts succeeded with mechanical reshewing with force up to 40N or subsequent effort to manually retrieve the filter.

Conclusions: Both time penetration of the IVC with organ contact/involvement and tine displacement of the IVC wall (tenting) with the tine adjacent to an organ without IVC penetration may both be grade 3 but likely have different clinical implications. MicroCT improved visualization allowing more accurate grading. Comparison of microCT data to MDCT imaging in the swine model may lead to better interpretation of the clinical appearance of IVC filter tine on CT.

Abstract No. 653

A novel technique for transfemoral IVC filter placement to decrease tilting
E. Kim², S. Brejt¹, S. Reis³, S. Tulin-Silver¹, D. Sperling¹, J. Susman¹, J. Weintraub¹, D. Mobjley¹; ¹Columbia University/New York Presbyterian, New York, NY

Purpose: The purpose of this study was to evaluate the safety and efficacy of an over-the-wire technique for transfemoral IVC filter placement to decrease filter tilting. The tortuosity of the IVC and the change of angle from the femoral vein to the IVC are believed to play a large role in the tilting of the IVC filter after deployment, which may lead to more challenging retrievals.

Materials: This IRB-approved retrospective study included 78 consecutive patients with indications for IVC filter placement from 2015-2017. Thirty-nine consecutive, femorally-placed various types of IVC filters were placed without the over-the-wire technique–6 Tulip (Cook medical), 6 Celect (Cook), 1 Denali (Bard) and 26 Option (Argon) filters; and 39 consecutive Option (Argon) filters were placed transfemorally utilizing the over-the-wire technique for deployment. An exchange-length Bentzon wire was placed into the SVC and used for the over-the-wire deployment. After deployment and wire removal, a completion anterior-posterior IVC venogram was performed. All filters were placed in the infrarenal position. A line perpendicular to the long axis of the IVC was drawn across the topmost position of the filter from one lateral wall of the IVC to the contralateral wall. The percent of IVC filter tilting was calculated by dividing the deviation of the topmost part
of the filter from the midpoint of the line drawn perpendicular to the long axis of the IVC on the completion venogram by the diameter of the IVC. Safety was assessed based on the complication rate (hematoma, infection, etc).

**Results:** Transfemoral placements of IVC filters utilizing the over-the-wire technique had a lower deviation from the IVC midline (Mean = 9.8%, Median = 9.0%, Range = 0%-19.3%) than those filters placed not utilizing the over-the-wire technique (Mean = 19.9%, Median = 19.9%, Range = 0%-38%). There were no documented differences in the complications between the two groups.

**Conclusions:** Utilizing the over-the-wire technique is a safe and effective way to deploy an IVC filter from a transfemoral approach, which demonstrates a 10.1% decrease in tilting of the filter away from the midline of the IVC lumen compared to the non-over-the-wire technique.

---

**Abstract No. 654**

Fibrin cap disruption using the hangman technique for retrieval of apex embedded conical IVC filters: a highly effective technique even in filters with long dwell times

M. Doshi¹, K. Shah², P. Mohan³, J. Salsamendi⁴, S. Ghosh⁵, M. Kably⁶, T. Scagnelli⁷, R. Lencioni¹, G. Narayanan₈; ¹University of Miami, Miami, FL; ²Jackson Memorial Hospital, Miami, FL; ³University of Miami Miller School of Medicine, Miami, FL; ⁴University of Miami/ Jackson Memorial Hospital, Miami, FL; ⁵Univ. of Miami Miller School of Medicine, Coral Gables, FL; ⁶University of Miami- Miller School of Medicine, Miramar, FL

**Purpose:** Hangman technique is an advanced retrieval technique described for conical inferior vena cava (IVC) filters with endothelialized or embedded apex. It uses a subapical guide wire loop for disruption of fibrin cap attaching the filter apex to the IVC wall. Although efficient, the literature on this technique is scant. This study aims to demonstrate the efficacy and reproducibility of the Hangman technique for the retrieval of IVC filters with embedded apex, even the ones with long dwell times.

**Materials:** Retrospective review of IVC filter retrieval attempts between Jan 2014 and Aug 2017 yielded 319 cases. Hangman technique was used in 29 of these cases. Two filters were suprarenal and the rest were infrarenal. Filter types were Celect Platinum™ (Cook Inc., Bloomington, Indiana) (n = 11), Celect™ (Cook Inc., Bloomington, Indiana) (n = 6), Option™ELITE (Argon Medical Devices, Inc, Athens, Texas) (n = 6), Denali® (Bard Peripheral Vascular, Tempe, Arizona) (n = 2), Gunther Tu-lip® (Cook Inc., Bloomington, Indiana) (n = 2), Meridian® (Bard Peripheral Vascular, Tempe, Arizona) (n = 1) and ALN (ALN Implants Chirurgicaux, Ghisonaccia, France) (n = 1). Mean dwell time was 658 days (SD 974 days, range 68-4,753 days, N = 27).

**Results:** The technical success rate was 90% (26/29). Seven patients had prior unsuccessful retrieval attempts. There were no procedure related complications. Mean total procedure time was 81.7 min (27-210 min, N = 29). Mean fluoroscopy time was 37.4 min (10.3-96.3 min, N = 11). Amongst three failures, two Celect™ filters were successfully removed using standard loop-snare technique through the struts, and one Denali® filter was left in situ.

**Conclusions:** The Hangman technique is a safe, highly effective and reproducible technique for retrieving conical filters with embedded apices even after prolonged dwell times.

---

**Abstract No. 655**

Treatment of peristomal hemorrhage: a review of outcomes and comparison of two minimally invasive techniques

S. Young¹, J. Golzarian², J. Wong³, N. Frank⁴, M. Rosenberg⁵; ¹University of Minnesota, Edina, MN; ²University of Minnesota, Minneapolis, MN; ³N/A, Minneapolis, MN; ⁴University of Minnesota Medical School, Minneapolis, MN; ⁵University of Minnesota, Saint Paul, MN

**Purpose:** Development of peristomal variceal bleeding in patients who undergo ostomy formation and have or develop portal hypertension is common. While many different minimally invasive techniques have been described the data is sparse and no direct comparison between techniques has been made. This article aims to review and compare outcomes between percutaneous sclerotherapy and transjugular intrahepatic portosystemic shunt (TIPS) treatments.

**Materials:** After IRB approval 5 patients who underwent 9 sclerotherapy treatments and 7 patients who underwent TIPS placement for peristomal variceal bleeding were retrospectively reviewed. Data pertaining to the technical aspects of the procedure, demographics, and information regarding the underlying cause of ostomy and portal hypertension were collected. Treatment was considered a primary success if no further hemorrhage occurred.

**Results:** Sclerotherapy patients trended toward having a poorer nutritional status (albumin mean 2.04 and 2.95 g/dL in sclerotherapy and TIPS groups respectively p = 0.04) and worse liver function (total bilirubin 4.9 and 1.6 mg/dL in the sclerotherapy and TIPS group respectively p = 0.07). Primary success was statistically better in the TIPS cohort (100%) versus the sclerotherapy cohort (40%) (p = 0.04). One patient died of recurrent massive peristomal hemorrhage 6 months after initial sclerotherapy, and one patient required admission for hepatic encephalopathy following TIPS. There was no statistically significant difference in complications following TIPS and sclerotherapy (p = 1).

**Conclusions:** TIPS appears to be more effective than sclerotherapy in treating peristomal variceal bleeding. However, sclerotherapy may be an effective bridging technique for patients who have acute decompensation of liver function.

---

**Abstract No. 656**

Percutaneous cryoablation of fibro-adipose vascular anomaly: safe and effective therapy

C. Kaufman¹, R. Arnold², A. Froodham³, Z. Gizman¹, R. Hardman¹; ¹University of Utah, Salt Lake City, UT; ²Primary Children’s Hospital, Salt Lake City, UT; ³University of Utah HSC, Salt Lake City, UT

**Purpose:** Fibro-adipose vascular anomalies (FAVAs) are complex vascular malformations typically presenting with lifestyle limiting
pain and at times contractures. FAVAs are difficult to treat typically with poor response to sclerotherapy. Recently a small series of pediatric patients was published showing percutaneous cryoablation to be a safe and effective treatment. The purpose of our study was to evaluate the efficacy and clinical outcomes of image-guided cryoablation in pediatric and adult patients with FAVA either as primary therapy or after prior failed interventions.

Materials: A retrospective review was performed of all patients undergoing percutaneous image-guided cryoablation with pre-procedure imaging or biopsy consistent with FAVA from 10/2014 to 9/2017 at two institutions. There were 10 patients’ ages 9-40 (mean age 22.2 years) and 13 ablations. Pre-procedure, intra-procedural, and, when available, follow-up imaging was reviewed. EMR review was performed to determine demographics, indication, prior treatments both interventional and surgical, symptoms, and clinical response after the procedure and at any subsequent follow-up visits, as well as any complications. Response was categorized as complete resolution of pain, marked improvement, and 1 patient was lost to follow-up. There were no major complications. Previously limited by pain or no improvement (now able to perform activities previously limited by pain or no longer requiring pain medication), minimal improvement, and no improvement.

Conclusions: Cryoablation is safe and effective for treatment of adult and pediatric FAVA lesions either as primary therapy or after failed prior interventions.

Impact of venous collaterals on clinical outcomes in Paget-Schroetter syndrome
D. Phadke1, D. Sheeran3, L. Wilkins3, J. Kern4, J. Angle3; 1University of Virginia, Charlottesville, VA

Purpose: Effort thrombosis, Paget-Schroetter syndrome (PSS), is an axillo-subclavian venous thrombosis often following repetitive and vigorous use of the upper extremities. The development of collateral venous circulation is known to occur around the region of first rib impingement, but the effect these collaterals have on thrombosis and surgical outcomes is unknown. The object of this study was to characterize the effect of venous collaterals on the success of thrombolysis and the rate of reinterventions after surgery in patients with PSS.

Materials: Single-center retrospective study of all patients presenting with the clinical diagnosis of PSS receiving catheter-directed thrombolytic therapy (CDT) from 2007 through 2017. Patients receiving prior surgical intervention were excluded. The indication for all primary procedures was pain. The indications for repeat ablation was residual pain (n = 2) and ablation of another site (n = 1). Cryoablation was performed under ultrasound (n = 4), CT (n = 8), or combined ultrasound and CT guidance (n = 1). Five of the 10 patients had prior surgical resection, sclerotherapy, or embolization with recurrence of symptoms. Three patients had a complete response, 6 patients had marked improvement, and 1 patient was lost to follow-up. There were 6 minor complications including temporary numbness, scab at the access site, hematoma, and skin discoloration that resolved. There were no major complications.

Conclusions: Cryoablation is safe and effective for treatment of adult and pediatric FAVA lesions either as primary therapy or after failed prior interventions.

Results: CDT was performed in 35 extremities (34 patients) with a success rate of 100%. Pre-procedure venogram showed 27 extremities with low-grade collaterals and 8 with high-grade collaterals. The reintervention rate within 12 months for extremities with high-grade collaterals was 88% (7 of 8), significantly higher than those with low-grade collaterals, 41% (11 of 27, p = 0.021). There was a significant decrease in the severity of collateralization post thrombolyis (p = .048) and within 30 days postoperatively (p = .038).

Conclusions: The severity of venous collateralization on presenting venogram in patients with PSS does not appear to affect success rates of initial CDT, but may be predictive of long-term patency of the affected extremities. CDT seems to be effective in reducing collateral burden; however, patients with severe collateralization on presentation are more likely to need reintervention.

Investigating possible associated factors of decreasing fibrinogen levels during catheter-directed thrombolysis: a single-institution experience
W. Johnson3, M. Bader1, D. Allen3; 1Tufts Medical Center, Boston, MA

Purpose: Fibrinogen is routinely monitored during catheter-directed thrombolysis (CDT) as a surrogate for potential significant bleeding events (1). The primary purpose of this study is to analyze possible causes of decreasing fibrinogen during CDT.

Materials: Retrospective review of patients that underwent endovascular arterial and venous infusion CDT between 2010 and 2016 at an academic medical center was performed after IRB approval. 43 male and 40 female subjects were selected with 91 total encounters, of which 87 had available fibrinogen data; of those, 48 interventions were venous and 39 were arterial. Patients ranged between 11 and 87 years old upon intervention. Baseline fibrinogen and follow-up levels during tPA infusion were documented. Fibrinogen level <150 mg/dL was selected as a primary endpoint, as it serves as a threshold for dose reduction at our institution. Chi-square analysis was performed to evaluate significance of fibrinogen changes with respect to several factors. Additional comparisons of total tPA dose and infusion time was performed with two-way heteroscedastic t-test.

Results: 52 patients underwent CDT with a Cragg-McNamara catheter, 18 with an EKOS catheter, 9 with both, and 8 with other infusion catheter types. Fibrinogen reductions below 150 mg/dL were documented in 34 of 87 cases, with a significant association with EKOS use (p = .002) and venous thrombolyis (p = .0003). On average, fibrinogen level decreased by 55.4% in EKOS cases versus 35.1% in all other cases (p = 0.007). There was no significant difference when comparing those who underwent bolus tPA administration via power pulse delivery or concurrent heparin infusion (p = .09, p = .5). There was no significant difference when comparing average total tPA dose or average duration of lysis (p = 0.91, p = 0.49).

Conclusions: Although its utility as a marker for impending bleeding events is debated, fibrinogen is routinely monitored during CDT (1, 2, 3, 4). Variables our data suggested might be related to decreasing fibrinogen levels are EKOS infusion catheter use or venous thrombolysis; thus, interventionalists may choose to more
closely monitor fibrinogen levels during ultrasound-enhanced or venous CDT.

Abstract No. 659

Indigo mechanical thrombectomy device in children: an initial experience
C. Ortiz¹, K. Kukreja²; ¹Baylor College of Medicine, Houston, TX; ²Texas Childrens Hospital, Bellaire, TX

Purpose: Penumbra’s indigo device for mechanical thrombectomy has been successful in stroke interventions. However, use in deep venous thrombosis (DVT) for children has been limited due to the large size of the device and unknown feasibility. Another concern has been the significant blood loss during aspiration. We intend to assess technical feasibility, clinical outcomes, and safety from our initial experience with the indigo device for treating upper extremity (UE) and lower extremity (LE) DVT in children.

Materials: Chart review revealed 10 children (11 limbs) underwent indigo catheter mechanical thrombectomy at a tertiary care pediatric hospital from January 2016 to July 2017. Clinical and imaging data was reviewed. No patients were excluded. Among 5 boys and 5 girls (mean age 16.2 years, range 13–18 years), two 6-french indigo catheters and nine 8-french indigo catheters were used. Venograms obtained during the intervention were graded by assessing clot burden in 7 venous segments before and after mechanical thrombectomy with the following scale: grade 1 (<50% thrombolysis), grade 2 (50–99%), and grade 3 (100%). Technical success was set as greater than 50% thrombolysis.

Results: There was technical success in 3 UE and 6 LE limbs (81.8%) with grade 2 improvement in 8 limbs (72.7%) and grade 3 improvement in 1 limb (9.1%). Grade 1 improvement was present in 2 LE limbs (18.2%). Catheter-directed pharmacotherapy (6 limbs) and balloon angioplasty (7 limbs) were combined with the indigo device to further decrease clot burden. In patients with a preoperative and postoperative hemoglobin check (n = 8), there was a significant 48-hour change: 10.4 ± 1.3 g/dL preoperative to 7.9 ± 0.9 g/dL postoperative (p<0.001). Two patients required blood transfusions within 48-hours and responded well with no further complications. One transfused patient had a low hemoglobin (8.0 g/dL) prior to the procedure. No deaths or events of acute kidney injury occurred.

Conclusions: In this limited pediatric population, indigo device for DVT in older children is safe and technically feasible. Further quantification of blood loss in children may increase use of this device, reducing the need for adjuvant infusion therapy to resolve DVT.

Abstract No. 660

Initial experience with Arrow ClearClot over-the-wire thrombectomy device in an in vivo model of ilio caval thrombosis
G. Nadolski¹, A. Salute², T. Robertson³, S. Trerotola⁴; ¹University of Pennsylvania, Philadelphia, PA; ²Telefex, Reading, PA; ³Telefex, Inc., Reading, PA; ⁴University of Pennsylvania Medical Center, Philadelphia, PA

Purpose: To describe the initial experience testing ClearClot (CC) over-the-wire thrombectomy device in an in vivo model of ilio caval thrombosis.

Materials: An IACUC-approved prospective evaluation of the CC over-the-wire thrombectomy device (Telefex, Reading, PA) was performed at an independent GLP approved laboratory. Argon CleanerXT was used as a control device. Iliocaval thrombosis was created in 4 adult female swine by implating an occlusion balloon in the IVC inferior to the renal veins and injecting 2000 units of thrombin inferior to the inflated balloon. The wire and balloon ports of the catheter were capped and implanted in a subcutaneous pocket. An IVC filter was placed superior to the renal veins via a jugular vein approach at the time of clot creation. 7 days after clot creation, thrombectomy was performed (3 ClearClot, 1 CleanerXT). Before and after thrombectomy, pulmonary arteriography was performed. Following thrombectomy, animals were euthanized. Gross pathology and histologic analysis was performed by an independent board-certified pathologist who graded vein occlusion on a scale of 0 to 4 with 0 being no thrombus and 4 being 75-100% occlusion with thrombus.

Results: Prior to thrombectomy IVC occlusion was present in all animals. Angiographically, CC restored venous flow in all animals with percent occlusion after thrombectomy of <10% in two animals and 25% in the other. No venous flow was established with the control device, with percent occlusion estimated at 90%. Histologically, the mean vein occlusion score for the CC device was 0.95 compared to 1.79 in the control device. No segmental emboli were identified in all animals tested with CC. One larger embolus (6 × 4 mm) in the main right PA occurred in the animal treated with the CleanerXT. No detectable tissue ischemia was seen in the lungs. No intraprocedural mortality occurred. Histologically, no clinically meaningful vascular trauma related to CC device use was observed.

Conclusions: Initial experience with the ClearClot thrombectomy device demonstrated the ability to safely restore flow in completely occlusive ilio caval thrombosis in an animal model.

Abstract No. 661

UCLA pulmonary embolism response team: initial experience
E. Ihenachor¹, T. Wang², S. Chang², M. Calfon-Press², J. Moriarty²; ¹David Geffen School of Medicine at UCLA, Los Angeles, CA; ²UCLA Ronald Reagan Medical Center, Los Angeles, CA; ³UCLA Medical Center, Los Angeles, CA

Purpose: There is considerable clinical equipoise surrounding the triage, risk stratification and correct treatment protocols for patients with acute pulmonary embolism (PE). A multidisciplinary UCLA pulmonary embolism response team (UPERT) was established as an interdisciplinary approach to the assessment and management of acute PE.

Materials: UPERT is activated for patients who meet criteria for submassive or massive PE. The attending multidisciplinary on-call team reviews the patient data. Consensus opinion on patient risk and treatment option is reached.

Results: From 2/23/17 to 9/12/17, UPERT was activated for a total of 20 patients (11 male, 9 female), mean age 48.5 (range, 11-87). Median time from UPERT activation to completion of
Endovascular revascularization of challenging superficial femoral artery occlusive disease in critical limb ischemia

N. Golewale¹, A. Harding², L. Peters³; ¹Radiology, Incorporated Director, Vascular Interventional Radiology Elkhart General Hospital, Elkhart, IN; ²Radiology, Incorporated Vascular Interventional Radiology Elkhart General Hospital, Elkhart, IN; ³Radiology, Inc. Radiology, Incorporated Vascular Interventional Radiology Elkhart General Hospital, Elkhart, IN

Purpose: Purpose of our study is to report experience and technical success in endovascular revascularization of TASC C and D superficial femoral artery (SFA) lesions in patients with critical limb ischemia (CLI).

Materials: All patients who underwent SFA revascularization by endovascular approach over a period of 12 months for TASC C and D lesions in CLI patients were included. Patient's risk factors such as smoking and diabetes, chronic renal failure and symptom classification based on Rutherford category were reviewed. Technical details of each procedure including method of crossing the diseased SFA, need for reentry devise, method of lumen recannalization, complications and clinical status on follow up were reviewed.

Results: 16 patients and 21 limbs were included. SFA endovascular revascularization was performed in 14CLI patients (Rutherford 5 or 6). Twelve limbs with TASC C disease and 9 TASC D diseased limbs were treated. Diabetes and smoking history were found in majority of these patients (12). Chronic renal insufficiency was seen in 7 of these patients. Technical success was 95% for crossing and revascularization. There was one failure to cross a TASC D lesion. "wire and catheter" technique were utilized in all cases without "crossing device" utilization. Treatment of choice was operator dependent which included drug coated balloon angioplasty, Atherectomy and Stent placement. All except one limb required reentry device. Pedal access retrograde adjunct was required in 7 limbs with initial failure of antegrade crossing.

Complications: Majority of CLI patients have underlying comorbidities that makes vascular bypass less attractive option. Pedal access retrograde adjunct significantly increases procedural success. Even in complicated SFA lesions, a well planned endovascular procedure has a high success rate.

Abstract No. 663

Endovascular treatment with stent-graft for traumatic femoral arteriovenous fistula

J. Shin¹; ¹Hallym University Dongtan Sacred Heart Hospital, Seoul, Republic of Korea

Purpose: To assess the effectiveness and safety of endovascular treatment with stent-graft for arteriovenous fistula (AVF) of femoral artery following trauma.

Materials: From March 2013 to June 2017, endovascular treatment of traumatic AVF of femoral artery was performed in nine patients (M:F = 6:3; mean age, 52.8 years). The AVFs of femoral artery were diagnosed by computed tomography (CT) and/or color doppler ultrasonography (US). All patients had previously failed attempts of US-guided compression. Placement of graft-stent was performed by a contra-lateral femoral artery retrograde approach and cross-over technique. Self-expandable graft-stents were used in all patients.

Results: The types of trauma were penetrating injury (n=5), fall (n=2), contusion (n=1), and car accident (n=1). Fistulas were located in the superficial femoral artery in 5 cases, in the common femoral artery in 2 cases, and in the deep femoral artery in 2 cases. Technical success was achieved in all 9 patients. Complete repair of the fistula was accomplished immediately in 8 of 9 cases. One patient showed incomplete closure of fistula after one graft-stent placement, and underwent additional placement of a longer graft stent with successful result. Post-procedural angiography demonstrated no further visualization of fistula in all patients. There were no procedure-related complications, and there has been no migration, deformity or occlusion during the follow-up period.

Conclusions: Placement of stent-graft in the management of AVF of femoral artery following trauma is an effective and safe therapeutic method as a minimally-invasive alternative to surgery in selected patients.

Abstract No. 664

Elective bronchial artery embolization for hemoptysis in cystic fibrosis: is there a benefit over emergent embolization?

I. Babin¹, R. Shaikh²; ¹SUNY Upstate, Department of Radiology, Syracuse, NY; ²Boston Childrens Hospital, Boston, MA

Purpose: To assess the effectiveness and safety of elective bronchial artery embolization for hemoptysis in cystic fibrosis (CF) compared to emergent embolization.

Materials: A retrospective review of all patients with hemoptysis and bronchial artery embolization performed at our institution between 2010 and 2018 was performed.

Results: 15 patients were identified with hemoptysis, of which 13 underwent bronchial artery embolization. The indications for embolization were chronic hemoptysis in 12 patients and acute hemoptysis in 1 patient. The technical success rate was 100%. No complications were observed during the procedure. Follow-up evaluations showed a decrease in hemoptysis in 9 patients, with 4 patients achieving complete resolution.

Conclusions: Elective bronchial artery embolization for hemoptysis in cystic fibrosis is a safe and effective treatment option, with a similar effectiveness compared to emergent embolization.
**Purpose:** Hemoptysis is a well known complication of late stage cystic fibrosis, and can be acutely life threatening if not appropriately treated. Bronchial artery embolization (BAE) has become a first line treatment for patients with life threatening hemoptysis or those refractory to conservative management. However its use for non-critical management of hemoptysis remains unclear. This study compares outcomes between emergent procedures performed for life threatening hemoptysis and elective procedures performed for non life threatening hemoptysis in cystic fibrosis patients.

**Materials:** A retrospective chart review of 34 bronchial artery embolization in 18 patients was performed. Procedures were subdivided into two groups – those requiring emergent procedures for life threatening hemoptysis and those who received elective procedures for nonlife threatening hemoptysis. Emergent was defined as massive hemoptysis (>250cc/24h) or hemodynamic instability. Pre-procedure variables, procedure variables, and outcomes were analyzed.

**Results:** There was no significant correlation between disease severity and amount of hemoptysis or outcomes. All but one patient had positive sputum cultures. BAE was performed emergently in 8 cases and electively in 26. Seven patients required re-embolization on 16 different instances. The average time between re-embolization was 249 days in the elective group and 93 days in the emergent group, although results did not show statistical significance ($p=0.6$). A lower rate of ICU admission was seen in the elective group compared to the emergent group ($p=0.001$). The average length of stay after procedure was 9.8 days in the elective group compared to 23.4 days for the emergent group, although results were not significant ($p=0.15$). There was a trend towards significance with decreased number of patients requiring intubation in the elective group ($p=0.09$).

**Conclusions:** Bronchial artery embolization is a viable and effective technique for treatment of non–life-threatening hemoptysis in cystic fibrosis patients. Benefits of early intervention before hemoptysis becomes life threatening may offer advantages, and further research is needed.

---

**Abstract No. 665**

**Blunt splenic injury: clinical results of transarterial embolization, 4-years experiences in a single trauma center**

C. Jeon¹, C. Kim¹, H. Kwon¹, J. Hwang²; ¹Pusan National University Hospital, Busan, Republic of Korea; ²Konkuk University Medical Center, Seoul, Republic of Korea

**Purpose:** Splenic embolization can increase non-operative salvage for hemodynamically unstable blunt splenic trauma patients. However, its efficacy and complications are not clearly defined. A retrospective single center review was performed to delineate the benefits and risks of splenic embolization.

**Materials:** A retrospective electronic medical record review of all patients undergoing splenic embolization between April 2013 and March 2017 at a Korean regional trauma care center was performed. Reviewed results included patient demographics, initial and follow-up CT scan results, angiographic findings, embolization techniques, and clinical outcomes including splenic salvage rate and procedure-related complications.

**Results:** A total of 94 patients were reviewed. The majority of patients were young male involved in motor vehicle crashes. These patients had high abdominal computed tomographic grades of splenic injury and moderate to severe Injury Severity Scores. Over 90% of splenic injury grades 4 and 5 were successfully managed non-operatively. Patients under 40 years of age had a better clinical course than older patients. Redundant hemoperitoneum and the presence of other organ injury was associated with a high failure rate, even with embolization. The rate of splenic preservation were similar between nonselective temporary and selective embolization groups. Major complications included rebleeding in 10 patients; 6 splenic abscesses, with 4 patients requiring splenectomy.

**Conclusions:** Splenic embolization remains a safe and feasible interventional procedure to preserve viable spleen, especially in higher grade lienal injuries. Although complications of splenic embolization exist in some cases, these do not affect outcome. It remains to be proven in prospective or randomized clinical trials that include larger cohorts.

---

**Abstract No. 666**

**Long-term effects of Splenic artery embolization on splenic volume and platelet count**

B. Fox¹, A. Richardson², P. Mohan³; ¹Jackson Memorial Hospital, Miami, FL; ²University of Miami Miller School of Medicine, Miami, FL; ³Jackson Memorial Hospital/ University of Miami School of Medicine, Miami, FL

**Purpose:** The spleen is the most commonly injured visceral organ in blunt abdominal trauma. Increased susceptibility to infections following splenectomy has led to the shift towards spleen preserving procedures and Splenic Artery Embolization (SAE) is now the treatment of choice for hemodynamically stable patients with splenic injury. The aim of this study is to assess the long term effect of SAE on splenic volume and platelet count.

**Materials:** Using CPT codes, 66 patients who underwent SAE were identified, and 10 of those who had the necessary imaging and laboratory follow up were included in the study. Indications for SAE were trauma in 3 patients and portal hypertension in 7 patients. Splenic volume was calculated by automated volumetric software (Aquarius, TeraRecon, Inc.). Paired t-tests were performed to compare splenic volume and platelets before and after SAE.

**Results:** 10 patients (6M, 4F) with an average age of 53.6 years (SD 12.6) underwent SAE and were followed by repeat CT scan at an average for 29 months (SD 16.8). 8 SAE’s were performed in the proximal Splenic artery, while 2 SAE’s were done in selective branches of the Splenic Artery. 6 SAEs were performed using vascular plugs, 2 using microcoils and Gelfoam slurry, and 2 using coils only. All embolizations were technically successful with complete cessation of flow. Splenic volumes pre and post SAE at a mean follow up of 2.5 years measured by automated software from CT scans were 954.2 cm³ (SD 529.2) and 789.7 cm³ (SD 555.9), respectively ($p=0.49$). Overall, the spleen decreased in size by an average of 6.0% (SD 55) at 2.5 years. The mean pre and post SAE platelet counts were 166.4 and 185.4 respectively ($p=0.30$) at an average follow up of 3 months. Mean increase in platelet count was 21.8% (SD 32.2).

**Conclusions:** The splenic volume is not altered significantly by SAE at 2.5 year follow up, similarly the platelet count is also not
Abstract No. 667

Transcatheter arterial embolization for traumatic thoracic bleeding: 4-year experiences in a single trauma center
C. Jeon¹, C. Kim¹, H. Kwon¹; ¹Pusan National University Hospital, Busan, Republic of Korea

Purpose: We aimed to assess the safety and efficacy of transcatheter arterial embolization (TAE) for thoracic arterial hemorrhage following chest trauma.

Materials: From November 2013 to May 2017, 35 patients were referred to our interventional unit for thoracic arterial bleeding following chest trauma, based on clinical decisions and computed tomography (CT) images. A total of 35 patients (male:female ratio, 26:9; mean age, 52.9 years) who underwent selective TAE of thoracic hemorrhage-culprit arteries were included in this study. Technical and clinical success, complications, and 30-day mortality rate were analyzed.

Results: In 35 patients who underwent TAE, the main bleeding arteries were intercostal artery (n=23), internal mammary artery (n=11) superior and/or lateral thoracic artery (n=3), and bronchial artery (n=3). N-butyl-2-cyanoacrylate (NBCA) (n=21), gelatin sponge particles (n=7), microcoils (n=2), and combinations of NBCA, microcoils, or gelatin sponge particles (n=10) were used as embolic agents. Initial technical success was achieved in all 27 patients, with immediate cessation of bleeding. Eight patients showed rebleeding 1-2 days later and underwent repeated TAE with successful result. Clinical success rate was 85.7% (30/35), and five patients underwent thoracotomy for controlling residual bleed. There were no TAE-related major complications such as infarction or quadriplegia. The 30-day mortality rate was 5.7% (2/35).

Conclusions: Our clinical experience suggests that TAE used to control thoracic arterial bleeding following chest trauma is safe and effective as a minimally invasive treatment alternative to surgery.

Abstract No. 668

WITHDRAWN

Abstract No. 669

A comparison of particle embolization versus alcohol ablation for the treatment of renal angiomylipoma: a single-center retrospective review
M. Cellini³, J. Howe², K. Kim²; ³University of North Carolina, Durham, NC; ²University of North Carolina, Chapel Hill, NC

Purpose: To compare effectiveness of particle embolization versus alcohol ablation for the treatment of renal angiomylipoma (AML).

Materials: In this single center retrospective review, we analyzed 40 patients with AML who were treated with embolization by particles, alcohol ablation or a combination of the two. The picture archiving and communication system was used to retrospectively identify all patients at our institution who had been treated for AML. The pre-procedure and post-procedure imaging was then reviewed to determine if there was either a decrease in size or a decrease in enhancement of the treated AML. Patients without pre-procedure and post-procedure imaging were excluded.

Results: A total of 40 patients were retrospectively analyzed. There were 18 treatments with alcohol ablation (45%), 14 treatments with a combination of alcohol ablation and particle embolization (35%), and 8 treatments with only particle embolization (20%). Some patients underwent multiple treatments. Technical success rate was 100%. In 95% of the total cases, the AMLs decreased in size and/or showed decreased enhancement (n=38). The AMLs decreased in size; mean+/−SD AML size decreased 8.1+/−4.6 cm pre-embolization to 5.4+/−3.6 cm post-embolization. Only 1 patient that was treated with a combination of alcohol ablation and particle embolization increased in size of tumor on follow-up (2.5%). Additionally, only 1 patient treated with particle embolization alone experienced no change in size of tumor on follow-up (2.5%). Only two patients experienced major complications (5%, n=2), one treated with alcohol ablation and the other treated with a combination of alcohol ablation and particle embolization. Post-embolization syndrome (i.e. fever, nausea, vomiting, pain) was reported in 17.5% (n=7).

Conclusions: Selective arterial embolization is an effective and safe treatment option for renal AMLs. There is no significant difference in efficacy when treating with alcohol ablation, alcohol ablation and particle embolization, or particle embolization alone. The choice of the embolization technique should be left up to the discretion of the interventionalist based on experience and level of comfort.

Abstract No. 670

Optimal delivery rate and concentration of radiopaque beads for trans-arterial embolization
M. Doshi¹, P. Mohan², A. Amin³, A. Hanson⁴, N. Salas¹, R. Lencioni¹, G. Narayanan²; ¹University of Miami, Miami, FL; ²Universiy of Miami Miller School of Medicine, Miami, FL; ³University of Miami- Miller School of Medicine, Miami, FL; ⁴N/A, Miami, FL; ⁵University of Miami- Miller School of Medicine, Miramar, FL

Purpose: To determine how changes in the standard injection rate (1.0 mL/min), in the standard concentration (1:9), or the size of the LUMI beads affect the embolization volume.

Materials: A total of 9 Yorkshire pigs underwent fluoroscopy guided injection of LUMI radiopaque beads using 2 different LUMI bead sizes (R0=40-90 and R1=70-150 microns). Each animal was injected with 1 of 3 bead / Visipaque 320 contrast concentrations (1:4, 1:9, and 1:14) and at 1 of 3 injection rates (0.5mL/min, 1.0mL/min, and 1.5mL/min). Isovue contrast was used to position the catheter and allow for direct injection of the embolization beads into the arterial branch of the liver and kidneys. The larger LUMI beads (70-150 microns) were used to embolize the left kidneys and left hepatic lobes and the smaller LUMI beads

significantly altered at 3 months follow up. This study, although small, suggests that SAE is a safe intervention which can preserve splenic volume and function in the long term.
(40-90 microns) were used to embolize the right kidneys and right hepatic lobes. The animals were subsequently euthanized. The distance of the beads from the hilum was then evaluated with imaging and pathological correlation.

**Results:** Technical success rate was 100% (36/36). Embolization was achieved regardless of the injection rate and concentration. The complication rate after the embolization process was 0% (0/36). When measuring the effect of concentration on embolization volume, higher concentrations correlated with decreased embolization volumes in both the liver and kidney ($P = .014$ and $P = .001$, respectively). Smaller bead sizes also correlated with decreased embolization volume in both the liver and kidney ($P = .018$ and $P = .048$, respectively). However, different injection rates did not result in a statistically significant difference in embolization volume in either the liver or kidney ($P = .393$ and $P = .338$, respectively).

**Conclusions:** Increased concentration and smaller bead sizes appear to decrease embolization volume. However, changes in the injection rate do not appear to affect the embolization volume.

---

**Abstract No. 671**

**Uterine artery embolization for pedunculated subserosal leiomyomas: is it still contraindicated?**

**K. Han¹, M. Kim², J. Won³, D. Lee⁴, G. Kim⁵, K. Joon Ho⁶, H. Kim⁶, W. Choi¹, Y. Kim⁷, J. Lee⁸; ¹Severance Hospital, Seoul, Republic of Korea; ²Severance Hospital, Yonsei University College of Medicine, Seoul, Republic of Korea; ³Severance Hospital, Yonsei University College of Medicine, Seoul, Seoul; ⁴Seodaemun-gu, ⁵Severance Hospital, Seoul, Republic of Korea; ⁶Severance Hospital, Yonsei University College of Medicine, Seoul, Seoul; ⁷Severance Hospital, Seoul, Seoul; ⁸Severance Hospital, Yonsei University College of Medicine, Seoul, Seoul

**Purpose:** To evaluate the safety and efficacy of uterine artery embolization (UAE) for pedunculated subserosal leiomyomas (PSLs).

**Materials:** Of 1069 patients who underwent UAE for symptomatic leiomyomas or adenomyosis from 2007 to 2016, 55 patients (mean age, 40.3 ± 4.8 years) with 66 PSLs (mean diameter, 6.61 ± 2.04 cm) were enrolled in this study. Each PSL was categorized into either of two groups: high-risk PSL (stalk diameter <25% of the diameter of leiomyoma) and low-risk PSL (stalk diameter 25–50% of the diameter of leiomyoma). Postprocedural magnetic resonance imaging was performed 3 months after UAE. The rates of infarction and volume reduction were compared between PSLs and non-PSL dominant leiomyomas and between high-risk and low-risk PSLs. Complications related to PSLs were assessed.

**Results:** At a median follow-up of 96 days (range, 36–348 days) after UAE, none of the patients (0%) had complications related to PSLs, even among high-risk cases. Mean volume reductions of 38.2% and 38.4% were achieved for PSLs and non-PSL dominant leiomyomas, respectively ($P = 0.953$). There were three (5.5%) minor adverse events but none were related to PSL. There was no significant difference in volume reduction and infarction rates between low-risk and high-risk PSLs.

**Conclusions:** UAE is safe and effective in patients with PSLs even for high-risk cases (stalk diameter <25% of the diameter of leiomyoma). PSL should not be considered a contraindication for UAE.
insertion of microsheath into the SFA was measured. CFA diameter, cutis thickness, distance between arterial puncture site and CFA bifurcation, degree of CFA calcification, body mass index (BMI), and history of previous access were investigated to assess relationships with SFA access time.

**Results:** Technical success was achieved in 74 of 75 procedures (98.7%). Mean time for SFA access was 1.9 ± 0.6 minutes (range, 0.5–2.9). Additional fluoroscopic guidance was needed in one case (41.6 in BMI). There was strong positive correlation of BMI ($r = 0.74, P < 0.001$) and cutis thickness ($r = 0.7, P < 0.001$) with access time. The remainder of variables failed to reveal significant correlation with access time. There was one groin hematoma. Complications such as pseudoaneurysm or arteriovenous fistula were not observed.

**Conclusions:** Antegrade CFA puncture with subsequent SFA access conducted solely under US-guidance was feasible and safe. There was significant positive correlation between BMI, cutis thickness, and antegrade SFA access time.

### Abstract No. 674

**Recent technical advancements in endovascular stroke treatment are associated with a decrease in time to recanalization, contrast material volume, and incidence of contrast induced nephropathy**

V. Gupta, G. Jindal, Y. Serulle, J. Stoner, T. Miller, D. Gandhi; University of Maryland, Baltimore, MD; University of Pennsylvania, United States

**Purpose:** Due to the results of recent landmark trials on endovascular treatment (EVT) of acute stroke and given the rapid advancement of device technology, EVT is being performed more commonly and more rapidly now than ever before. Our purpose is to investigate the incidence of contrast induced nephropathy (CIN) in patient's undergoing EVT using the latest EVT devices. We investigated amount of contrast material (CM) and incidence of CIN before and after the incorporation of new, large bore, distal suction catheters (DSCs) in EVT of stroke with stent retrievers (SRs).

**Materials:** Retrospective review of a prospectively maintained database was performed on all patients undergoing EVT with SRs from April 2012 to April 2016, before and after the introduction of DSCs at our single institution. Data collected were age, gender, race, periprocedure CTAangiography, time from arteriotomy to recanalization (TR), CM volume, and serum creatinine (Cr) values at baseline and post procedure days 1 and 2. CIN was defined as a relative increase from baseline of 50% or absolute increase of 0.30 in Cr within the first 48 hours.

**Results:** A total of 119 patients were reviewed, 33 consecutively prior to DSCs and 86 consecutively after DSCs. No patients were excluded, and there were no crossovers. TR before and after DSCs was 61.4 min and 50.0 min, respectively ($p = 0.05$). Baseline Cr for patients before and after DSCs was 0.92 and 1.09, respectively. CM volume before and after DSCs was 157 mL and 122 mL, respectively ($p = 0.003$). CIN before and after DSCs was seen in 3 of 33 patients (9.09%) and 1 of 86 (1.2%) patients, respectively. ($p = 0.04$).

**Conclusions:** Recent advancements in EVT of stroke are associated with a relative decrease in TR, CM, and CIN. These findings suggest that risk of CIN in this patient population may be particularly dose dependent and warrants further investigation.
2.3 mm (range, 1.4-4 mm). Gradual, incremental dilatation was performed in 14 patients. The mean diameter of the largest balloon catheter used was 6.5 mm. Bare-metal stent was placed in one patient.

**Results:** Technical and clinical success rates were achieved in all patients. In two patients, reverse flow veins were dilated. Vessel rupture which could not be salvaged by balloon tamponade occurred in two patients and was subsequently treated with stent-grafts. There were no major complications.

**Conclusions:** Angioplasty of the collateral vein is effective in restoring function of failing hemodialysis fistula with obliterated outflow vein.

---

**Abstract No. 677**

Outback re-entry device for the treatment of central venous occlusion in hemodialysis patients

J. Kim¹, J. Won²; ¹Ajou University Hospital, Suwon, Gyeonggi-do; ²Ajou University Hospital, Suwon, Republic of Korea

**Purpose:** To report our institutional experience with the Outback re-entry device for the treatment of central venous occlusion in hemodialysis patients.

**Materials:** Since January 2013, 8 consecutive patients (4 males and 4 females, mean age: 63.2 years) receiving hemodialysis underwent endovascular treatment for central venous occlusion using the Outback re-entry device after failed attempts of guidewire traversal. The patients had been referred for percutaneous angioplasty due to increased venous pressure during hemodialysis in 4 patients and upper extremity swelling in 4 patients. The mean age of their fistulas since creation was 21.3 months. Six patients had previously received endovascular treatment for malfunctioning fistulas.

**Results:** Occlusion sites were in the subclavian vein (n=4) and brachiocephalic vein (n=4). In all patients, the guidewire was passed into the subintimal plane but could not be re-directed into the distal true lumen. The Outback re-entry device was used as a bail-out measure with technical success in all cases. All patients underwent balloon angioplasty; 6 of them had provisional bare metallic stent placement due to elastic recoil. The fistulas were functionally restored and arm swelling was relieved in all cases. Excluding three patients who were lost to follow-up, the fistulas were functional up to a mean period of 8.3 months. During this time, 4 patients underwent repeated intervention. There were no complications related to the procedure.

**Conclusions:** The Outback re-entry device is a feasible and safe bail-out option in patients who fail conventional techniques for wire traversal during endovascular treatment of central venous occlusion.

---

**Abstract No. 678**

Analysis of clinical workload of private practice interventional radiologists

J. Weinstein¹, A. Rozenberg², Z. Li³, D. Hansberry³, D. Eschelman⁴, D. Levin²; ¹Thomas Jefferson University Hospital, Philadelphia, PA; ²Thomas Jefferson University Hospital, Bryn Mawr, PA

**Purpose:** Recent changes in the training of interventional radiologists have increased the emphasis on improving technical and clinical skills. Given that most interventional radiology trainees will work in a private practice setting, we sought to characterize the clinical workload of private practice interventional radiologists.

**Materials:** The 15 largest private practices in 2015 were identified through Radiology Business Journal. Practice websites were reviewed to record physicians that were identified as interventional radiologists. The names were cross-referenced with the Medicare Provider Utilization and Payment Database, a publicly available data set that contains detailed information on each provider. For each interventional radiologist identified, we determined if diagnostic radiology was a component of their Medicare billing for 2014. Additionally, the two highest billed medical services (charge per examination multiplied by number of times performed) were recorded for each provider.

**Results:** Three practices were excluded, as they did not delineate which physicians practiced interventional radiology or did not have interventionalists on staff. Of the 148 self-identified interventional radiologists included in the analysis, 6 (4%) had not billed Medicare for any diagnostic exams. The remaining 142 (96%) had billed Medicare for interpretation of at least one type of diagnostic radiology examination. Of the 142 providers, only 52 (36%) had their top two billed exams to Medicare as interventional procedures. 50 of the 142 (35%) had both of their top two billed exams to Medicare as diagnostic examinations with 32 of the 50 (64%) providers in this category with their top billed exam as CT of the abdomen and pelvis.

**Conclusions:** Interventional radiologists at the largest private practices overwhelmingly interpret at least some diagnostic radiology examinations. Of these providers, more than half have a significant amount of their top billing to Medicare as diagnostic exams with a notable majority of their top billed studies being CT of the abdomen and pelvis. These findings reinforce the importance of diagnostic training for future private practice interventional radiologists.

---

**Abstract No. 679**

How subspecialized are academic interventional radiologists?

Z. Li¹, J. Weinstein², A. Rozenberg¹, D. Hansberry³, D. Levin¹; ¹Thomas Jefferson University Hospital, Philadelphia, PA; ²Thomas Jefferson University, Philadelphia, PA; ³Thomas Jefferson University Hospitals, Philadelphia, PA

**Purpose:** It is commonly believed that most academic interventional radiologists (aIRs) work exclusively within the realm of their subspecialty training while private practice IRs (pIRs) split their time between diagnostics and procedures. Recently, emphasis has been placed on well-rounded training to accommodate the rapidly changing practice environment in IR. In this study, we characterize the workload and case complexity of aIRs, the knowledge of which is helpful to guide trainees throughout their training.

**Materials:** The 19 largest aIR divisions were identified through the IR Training Directory on the SIR website. A total of 166 aIRs...
was compiled by reviewing each departmental website. Manual search on the Medicare Provider Utilization and Payment Database revealed all services billed to Medicare by each provider in 2014. The 2 highest billed services were recorded based on charge per exam and number exams performed. For allRs who also provide diagnostic interpretations, the 2 highest billed diagnostic exams were also recorded.

**Results:** Among the 166 allRs, the 2 highest billed Medicare services include central venous catheter placement (26%), chest port placement (14%), balloon dilation of vein (13%), insertion of catheter into abdominal pelvic or leg artery (10%), tumor embolization (10%), diagnostic study (9%), and other less common procedures (each < 5%). Interestingly, 74 out the 166 allRs (45%) billed at least one type of diagnostic exams, among which are extremity venous ultrasound (21%), chest radiograph (17%), CTA abdomen pelvis with runoffs (14%), CT abdomen pelvis (10%), CTA abdomen pelvis (10%), CT chest (6%), extremity arterial ultrasound (5%), CTA chest (5%) and other less common exams (each <5%).

**Conclusions:** Central venous catheter, chest port placement, venous intervention and tumor embolization are the most commonly performed procedures among allRs. Interestingly, nearly half of the allRs interpret at least one type of diagnostic exam, the majority of which are vascular. These findings, by no means, suggest narrowing down the focus for IR trainees but rather reinforce the importance of well-rounded training including diagnostic competency.

---

**Abstract No. 680**

**Comparison of parental leave statements by national medical specialty societies**

C. Hyman1, G. Soares2, T. Murphy3; 1Brown University, Providence, RI; 2Alpert Medical School Brown University, Barrington, RI; 3Lifespan/Alpert Medical School at Brown University, Providence, RI

**Purpose:** In May of 2017, the Society for Interventional Radiology (SIR) and its Women in Interventional Radiology section issued an official position statement outlining recommended policies for parental leave. This statement encourages institutions and practices to support interventional radiologists who choose to become parents.

**Materials:** The websites of the 119 American medical specialty societies recognized by the American Medical Association’s House of Delegates were searched for keywords “parental leave,” “maternity leave,” and “paternity leave.” To ensure completeness, a second search of the society name plus the same keywords were performed in the search engine Google©. Position statements were analyzed based on their recommendations in nine categories.

**Results:** Seven out of the 119 specialty societies (5.9%) had publicly available parental leave statements. The oldest was from 1989 and the most recent was from the SIR. All statements recommended that parental leave policies be explicitly stated in employment contracts. The responsibility of the physician to notify the employer of the employee’s intent to take leave for the birth or placement of a child was uniformly required. Prenatal schedule flexibility was advised in 85.7%. Of the seven set six-weeks minimums for leave, and only the American College of Surgeons (ACS) increased this to 8 weeks for cesarean. Three extended this minimum to paternity leave. The American Academy of Family Physicians was the only to recommend that parents should have make-up call coverage; the rest recommended against. Three recommend a minimum of six weeks of pay, and three did not make recommendations regarding pay. The ACS stated that pay should be negotiated by practices. Two were explicitly directed at residents, one to both residents and practicing physicians, and the rest did not include residents. Four included adopting and fostering parents.

**Conclusions:** Few professional societies have issued parental leave statements. The parental leave position statement issued by the SIR is one of the most comprehensive and inclusive parental leave statements. To improve its inclusiveness, clarification on the positions applicability to residents and fellows could be amended.

---

**Abstract No. 681**

**Predictability of D-dimer levels in detecting pulmonary embolism in the sickle cell population.**

S. Altaf1, S. Sakib1, Y. Levy1, M. Sadler2; 1Newark Beth Israel Medical Center, Newark, NJ; 2NBIMC, Newark, NJ

**Purpose:** An elevated D-dimer level is used as a first line screening tool for patients suspected of having a thrombo-embolic event in the emergency department. However, d-dimer levels can be constantly elevated in patients with sickle cell disease. We investigate whether elevated d-dimer levels can be used for screening a patient with sickle cell disease who presents with acute shortness of breath and other symptoms of Pulmonary Embolism (PE).

**Materials:** A retrospective analysis of all adult patients undergoing a CT pulmonary angiogram with a history of sickle cell disease was performed. The study period was from 07/2012 to 07/2017 and a total of 103 patients was identified. Patients who had a prior known history of venous thrombotic disease or PE were excluded from the study. Patients who were not screened with a d-dimer level prior to their scan were also excluded.

**Results:** A total of 32 patients had elevated d-dimer levels and symptoms suggestive of PE. Out of the 32, only 3 had pulmonary emboli on their subsequent CT pulmonary angiogram. 12 patients had a new infiltrate in the lungs. The scan was negative in the remaining patients.

**Conclusions:** Elevated d-dimer levels are poorly predictive of PE in the sickle cell disease population and should not be used as a screening criterion in these patients.

---

**Abstract No. 682**

**Workup of GI bleeds: nuclear medicine vs. CT angiography**

R. Sood1, F. Razjouyan1, H. Narayan1, D. Scher1, A. VenBrux1, A. Chun1, S. Sarin1; 1The George Washington University Hospital, Washington, DC

**Purpose:** With an aging population acute gastrointestinal bleeding (GIB) requiring hospitalization and treatment continues to rise with an incidence of approximately 36/100,000. The diagnostic imaging gold standard has historically been radionuclide labeled red
Abstract No. 684

Imaging surveillance following radiofrequency ablation of renal cell carcinoma

R. Knebel¹, R. Lurvey¹, J. McGahan¹, C. Evans¹; ¹UC Davis, Sacramento, CA

Purpose: The purpose of this study is to review our institution's ten-year experience with imaging surveillance following percutaneous radiofrequency ablation for spontaneous stage T1a renal cell carcinoma, and apply risk stratification based upon the post-procedure CT scan, modified renal nephrometry score, and tumor histology.

Materials: All renal radiofrequency ablation procedures performed at our institution from 1/1/2005 through 7/31/2015 were reviewed, including pathology and follow-up imaging. Inclusion criteria were all cases of T1a biopsy-proven renal cell carcinoma with at least one follow-up imaging study after the post-ablation scan. Exclusion criteria were benign or indeterminate pathology, Von Hippel Lindau syndrome (VHL), no imaging follow-up available, prior thermal ablation on the same lesion, or RFA discontinued due to technical factors. Cases meeting inclusion criteria were evaluated with mRENAL Nephrometry score, tumor histology, and post-therapy CT scan. Time lag to detection was calculated for each instance of recurrence.

Results: 52 cases (in 49 patients) of T1a biopsy-proven renal cell carcinoma status post radiofrequency ablation with at least one follow-up imaging study met the criteria for inclusion. 7 cases of RCC recurrence were identified. Cases of disease recurrence had a statistically significantly higher mRENAL score (7.3 versus 6.0, two-tailed T-test p-value .0087). Recurrence was more likely in tumors with clear cell histology (5/18 versus 2/34 for other histology, Fisher exact test statistic value .0409). There were no cases of disease recurrence if the post-therapy CT scan was definitively negative.

Conclusions: The mRENAL Nephrometry score, tumor histology, and post-therapy CT scan inform the rate of tumor recurrence following radiofrequency ablation of T1a renal cell carcinoma. These data may be incorporated into the development of surveillance strategies to yield cost savings and decrease patient radiation exposure, while maintaining surveillance effectiveness.

Abstract No. 683

Effectiveness of arm positioning on evaluation of subclavian vein at upper extremity CT venography

M. Song¹, T. Seo², S. Park², H. Chung², S. Lee², E. Jung³; ¹Korea University Gyeyang Hospital, Seoul, Republic of Korea; ²Korea University Ansan Hospital, Ansan, Republic of Korea; ³Nowon Eulji Medical Center, Seoul, Republic of Korea

Purpose: To evaluate effectiveness of arm positioning on evaluation of subclavian vein at upper extremity CT venography.

Materials: Upper extremity CT venography was performed in 63 patients for evaluation of cause of upper extremity edema from May 2015 to June 2017, with a final study population of 60 patients (mean age, 59.1 ± 15.4 years; range, 29-87 years). CT venography was performed first with the arms elevated and then with the arms alongside the body in an attempt to increased visualization of subclavian vein. Medical records were retrospectively reviewed. The cause of edema and diameter of right subclavian vein at costoclavicular space were evaluated on chest CT images. Statistical analysis was performed.

Results: Causes of edema in patients were no causes (n=30), compression of subclavian vein by lymph nodes (n=13), thrombosis of subclavian vein (n=10), Occlusion or stenosis of subclavian vein (n=4), invasion of tumor into subclavian vein (n=2), and compression of brachiocephalic vein by mediastinal mass (n=1). Mean diameter of right subclavian vein was 6.64 mm (range, 2.07-11.68 mm) in elevated arms and was 11.49 mm (range, 4.29-17.40 mm) in arms alongside the body. Mean diameter ratio between positions of arms was of 0.58 (range, 0.16-1.09). Difference of diameters of right subclavian vein was statistically significant vein between with the arms elevated and with the arms alongside the body (p < 0.001). Eight cases of stenosis of right subclavian vein were detected on CT images with elevated arms. Among these, six cases of stenosis of right subclavian vein were not evident on CT images with the arms alongside the body.

Conclusions: Positioning of arms alongside the body seems to be needed in evaluating subclavian vein and preventing miss-diagnosis of stenosis of subclavian vein during upper extremity CT venography.
Imaging Surveillance Following Radiofrequency Ablation of Renal Cell Carcinoma

<table>
<thead>
<tr>
<th>Case#</th>
<th>Tumor size (cm)</th>
<th>mRENAL score</th>
<th>RCC histology</th>
<th>Post-RFA CT</th>
<th>RFA to detection (days)</th>
<th>Lag to detection (days)</th>
<th>Size at detection (cm)</th>
<th>Recurrence strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.5</td>
<td>8</td>
<td>Clear cell</td>
<td>Indeterminate</td>
<td>1138</td>
<td>243</td>
<td>3.5</td>
<td>Surveillance</td>
</tr>
<tr>
<td>2</td>
<td>3.1</td>
<td>8</td>
<td>Clear cell</td>
<td>Not performed</td>
<td>76</td>
<td>76</td>
<td>3.2</td>
<td>Nephrectomy</td>
</tr>
<tr>
<td>3</td>
<td>2.9</td>
<td>7</td>
<td>Clear cell</td>
<td>Not performed</td>
<td>458</td>
<td>406</td>
<td>0.9</td>
<td>Repeat RFA</td>
</tr>
<tr>
<td>4</td>
<td>3.1</td>
<td>9</td>
<td>Clear cell</td>
<td>Indeterminate</td>
<td>238</td>
<td>238</td>
<td>1.7</td>
<td>Surveillance</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>7</td>
<td>Clear cell</td>
<td>Positive</td>
<td>1</td>
<td>1</td>
<td>0.3</td>
<td>Surveillance</td>
</tr>
<tr>
<td>6</td>
<td>2.7</td>
<td>7</td>
<td>RCC NOS</td>
<td>Not performed</td>
<td>186</td>
<td>186</td>
<td>1.9</td>
<td>Repeat RFA</td>
</tr>
<tr>
<td>7</td>
<td>2.1</td>
<td>4</td>
<td>Papillary</td>
<td>Not performed</td>
<td>271</td>
<td>271</td>
<td>1.6</td>
<td>Surveillance</td>
</tr>
</tbody>
</table>

Abstract No. 685

In vitro bovine liver experiment of cisplatin-infused and normal saline-infused radiofrequency ablation with an internally cooled perfusion electrode

J. Yi1, H. Hong2, M. Kim1, E. Chung1; 1Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, Seoul, Seoul; 2Kangbuk Samsug Hospital, Sungkyunkwan University School of Medicine, Seoul, Seoul

Purpose: Cisplatin is an effective agent for the treatment of many malignant tumors and is mainly administered through intraarterial or intravenous route. Internally cooled perfusion electrode allows interstitial solution infusion during radiofrequency ablation (RFA). Purpose of this study was to evaluate the influence of cisplatin-infused and normal saline-infused radiofrequency ablation with internally cooled perfusion electrode on the size of ablated lesions.

Materials: Using a 200W generator, thirty ablation zones were divided into three groups of 10 each and created as follows: group A, RFA alone with 16 gauge monopolar internally cooled electrode; group B, cisplatin-infused RFA with 16 gauge internally cooled perfusion electrode; and group C, normal saline-infused RFA with 16 gauge internally cooled perfusion electrode. RF was applied to the explanted bovine liver for 12 minutes. During RFA, cisplatin and normal saline were injected into tissue at a rate of 0.5 mL/min through the internally cooled perfusion electrode by injection pump. Dimensions of the ablation zone and technical parameters were compared between the three groups.

Results: In the cisplatin-infused RFA group, the ablation zone size was significantly larger than that of the RFA alone group but significantly smaller than normal saline-infused RFA group. The width of longitudinal section and volume were 3.39 ± 0.22 cm2 and 26.55 ± 4.62 cm3 in RFA alone group, 3.88 ± 0.32 cm2 and 36.45 ± 5.46 cm3 in cisplatin-infused RFA group, and 4.52 ± 0.50 cm2 and 49.44 ± 7.55 cm3 in normal saline-infused RFA group, respectively (p<0.05 between any two groups). The mean impedance in group A, B, and C were 60.0 ± 7.2, 50.3 ± 2.5, and 40.3 ± 4.0 Ω, respectively (p<0.05 between any two groups).

Conclusions: Cisplatin-infused RFA with internally cooled perfusion electrode created the larger size of ablation zone than that of monopolar RFA with an internally cooled electrode, but created the smaller size of ablation zone than that of normal saline-infused RFA.

Abstract No. 686

Retrospective comparison of radiofrequency ablation and microwave ablation for the treatment of colorectal liver metastases

L. Bonne1, K. De Paepe2, D. Koh3, J. McCall3, N. Fotiadis3; 1University Hospitals Leuven, Leuven, Belgium; 2The Royal Marsden Hospital, London, London; 3The Royal Marsden Hospital, London, United Kingdom

Purpose: Microwave (MWA) and radiofrequency (RFA) ablation are commonly used for the treatment of unresectable liver metastases from colorectal cancer (CRC). MWA has a few theoretical advantages over RFA (less heat sink, larger ablation zones, faster). However, limited data exists on this field. Our aim was to retrospectively analyse the safety and efficacy of MWA and RFA in the treatment of CRC liver metastases.

Materials: Patients with unresectable CRC liver metastasis who were treated with RFA or MWA between March 2006 and December 2016 were included. Medical records and imaging studies were reviewed retrospectively for demographic data, to assess for local tumour recurrence and overall survival and to evaluate ablation-related adverse events.

Results: 456 ablations were performed in 193 patients (123 men) with a median age of 66 (range 32-91). The majority of patients had a history of surgery of the primary tumour (n=170, 88.1%) and systemic chemotherapy (n=183, 94.8%). 68 patients had a history of liver surgery (35.2%). RFA was used in 343 patients (75.2%), MWA in 113 (24.8%). Median number of procedures per patient was 2 (range 1-10). Median lesion size was 17mm (range 3-80mm). Mean follow-up per lesion was 2.0 years in the RFA group and 1.3 years in the MWA group. Local tumour recurrence rate was 45% for RFA and 28% for MWA, with a hazard ratio of 0.6 in favour of MWA (95%CI 0.4-0.9). Two and five year overall survival rates from time of diagnosis were 88% and 35% for RFA and 89% and 66% for MWA, respectively. Complications were reported in 43 of 456 ablations (9.4%); in 8.2% of RF ablations (n=28) and 13.3% of MW ablations (n=15). Complications classified as CTCAE grade 3 or higher were: haemorrhage requiring surgery (n=1 for RFA), biloma (n=2 for RFA and MWA), biliary sticture (n=2 for RFA, n=1 for MWA), liver failure (n=2 for RFA, liver abscess (n=1 for RFA), pneumonia (n=2 for RFA) and pulmonary embolism (n=1 for RFA). Segmental portal vein occlusion (n=1 for RFA) and abscess (n=1 for MWA) were seen. Treatment success was 89% and 66% for MWA, respectively.
occlusion was only seen with MWA (n=2). One patient died due to multi-organ failure post RFA.

**Conclusions:** MWA could achieve better local tumour control compared with RFA in the treatment of CRC liver metastasis, with a slightly higher complication rate.

**Abstract No. 687**

The effect of renal cryoablation on kidney function outcomes: a retrospective review from a single center interventional oncology department

N. Cornish1, M. Hoy2, D. Sarkar3, S. Honig4, S. Sobolevsky5; 1Maimonides Medical Center, Staten Island, NY; 2N/A, Arlington, VA; 3Cooper University Hospital, Philadelphia, PA; 4N/A, New York, NY

**Purpose:** This single center retrospective review aimed to determine the favorability of renal function outcomes following renal cryoablation, to validate this technique as a safe renal function preserving procedure as compared to partial/radical nephrectomy, to determine the effect of tumor size on renal function, and report on the rate of complications.

**Materials:** A retrospective review of patients with renal masses treated with image guided percutaneous cryoablation between 2007 and 2013 was performed. A total of 121 tumors were ablated in 105 patients. Malignancy was confirmed via biopsy and pathology. The mean patient age was 70 years old. The mean Charlson Comorbidity Index was 6.6. Baseline BUN and Creatinine were measured for the cohort and compared to the post-procedural measurements. Clinical and imaging data were reviewed for outcome analysis.

**Results:** Mean tumor size treated was 3.15 cm in largest diameter (1.4-6.5 cm, SD 1.26). Of the 105 patients, 59 followed in the clinic for repeat labs within the first year. The mean GFR pre cryoablation according to the MDRD equation for the cohort was 60.49 ml/min/1.73 m² and mean GFR post ablation was 57.46 ml/min/1.73 m². The mean percent decrease was therefore 5.02 %. The mean percent decrease in large tumors (>4 cm) was 1.34%. Significant complications were observed in 15.2% (16/105) cases with significant hemorrhage/hematuria being the most common in 11.4% (12/105).

**Conclusions:** Little data has been reported on the effect on renal function status post cryoablation. In our study, renal cryoablation is shown to have a low rate of complications and a minimal decrease in mean GFR (5.02%) as compared to the reported mean decrease in GFR status post radical/partial nephrectomy (approximately 20%). Increasing tumor size was not associated with a decrease in GFR. Renal cryoablation should be considered as a low-risk intervention for renal masses that perseveres kidney function, especially in the elderly comorbid population who often have decreased baseline renal function.

**Abstract No. 688**

Technical effectiveness of navigation-assisted percutaneous ablation of malignant liver tumors

M. Haimerl1, L. Beyer2, P. Wiggermann2; 1University Regensburg, Regensburg, Bavaria; 2University Hospital Regensburg, Regensburg, Bavaria;

**Purpose:** To compare the technical effectiveness (absence of residual tumor tissue on contrast-enhanced CT and MRI performed 6 weeks after treatment) of CT-fluoroscopy guided and computer-assisted ablation of malignant liver tumors.

**Materials:** In a retrospective analysis 196 thermal ablations of liver tumors (172 microwave and 24 radiofrequency ablations) in 104 patients (23 women, 81 men, mean age 61 years) have been analyzed. 77 procedures were performed using CT-fluoroscopy by two interventional radiologists (> 300 ablations done), the other 119 cases were carried out with robotic guidance. All patients underwent 6-week follow-up examinations including contrast-enhanced computed tomography and MR imaging. The technical effectiveness was retrospectively evaluated in a consensus reading of two experienced radiologists.

**Results:** Follow-up after 6 weeks showed complete ablation in 101 of 119 (84.9%) of computer-assisted and in 56 of 77 (72.7%) of manual ablations with the difference being significant (p = 0.04).

**Conclusions:** The computer-assisted approach for thermal ablation of malignant liver tumors using stereotactic or robotic navigation is superior to CT-fluoroscopy guided manual approach concerning the technical effectiveness of ablation procedures.

**Abstract No. 689**

Long-term treatment outcome of combined transarterial chemoembolization and radiofrequency ablation for perivascular hepatocellular carcinoma

J. Choi1, S. Park1, J. Kim1, Y. Park1, J. Lee1, M. Song1, T. Seo2, C. Lee1, K. Kim1, C. Park1; 1Korea University Guro Hospital, Seoul; 2Korea University Guro Hospital, Seoul

**Purpose:** To retrospectively evaluate the long-term results of combined transarterial chemoembolization (TACE) and radiofrequency ablation (RFA) in the treatment of perivascular hepatocellular carcinoma (HCC).

**Materials:** This retrospective study was approved by our institutional review board and the requirement for informed consent was waived. Between March 2000 and May 2014, 106 perivascular HCCs were selected among 635 HCCs treated by combined TACE and RFA. The perivascular HCC is defined as HCC located less than 3 mm away from large vessels which diameter measuring ≥ 3 mm in axial CT/MR images. 107 perivascular HCCs from 105 patients were selected consisting of 71 men and 34 women; mean age 59.4 years old (range, 29–83). Technical success, overall adverse event rates, recurrence rates and local tumor progression within 24 months were assessed.

**Results:** The mean diameter of tumors was 1.9 ± 0.99 cm. The median follow-up time was 45.6 months (range 3.0–158.4). The technical success of RFA was achieved in 103 out of 106 cases (97.2%). The overall, 12- and 24-month local tumor progression rates are 13.4%, 1.2%, and 6.0%, respectively. The overall recurrence rate within 24-month is 32.9% and the adverse event rate within 24-month is 36.5%. There were no procedure-related major complications such as vessels or bile ducts injury.
Conclusions: Combined TACE and RFA seem to be an effective and safe treatment modality for perivascular HCC in terms of local tumor progress, overall recurrence, and disease-free survival.

Abstract No. 690

Complications and seeding risk after percutaneous liver biopsy in the oncological setting
L. Bonne1, K. De Paepe2, D. Koh3, J. McCall3, N. Fotiadis3, 1University Hospitals Leuven, Leuven, Belgium; 2The Royal Marsden Hospital, London, London; 3The Royal Marsden Hospital, London, United Kingdom

Purpose: Percutaneous biopsy of suspected liver metastases is a common practice for diagnostic purposes. Particularly, in the setting of oncological clinical trials, it is a relatively non-invasive method to obtain sufficient tissue for molecular analyses at regular set time points. However, various complications may occur, including seeding of the tumour along the biopsy tract. Only few reports exist on the actual incidence of seeding, on a limited number of tumor types. The aim of this study was to evaluate the technique's safety and risk of seeding.

Materials: All patients with an ultrasound or CT-guided liver biopsy between 2012-2016 were included. Medical records were reviewed retrospectively for post-biopsy complications and all follow-up imaging was re-assessed for the presence of seeding, defined as tumoral deposits in the biopsy needle tract.

Results: In total 782 biopsies were performed in 550 patients (282 women, 268 men; mean age of 61 years), 43.9% (343/782) for trials and 56.1% (439/782) for diagnostic/molecular purposes, 93.7% (733/782) were diagnostic, revealing malignancy in 96.9% (710/733). Number of biopsies per patient ranged between 1 (n = 387) to 7 (n = 1), a co-axial system was used in 70.6% (552/782) and multiple passes in 29.4% (230/782). Complications were reported in 8.8% (69/782), more often pain (4.7%) and hypotension/vasovagal (2.3%). Admission and/or re-intervention were needed for more severe complications as bleeding (1.0%), sepsis/fever (1.1%), pulmonary embolism (0.3%) and pneumothorax (0.4%). Seeding was seen in 1.1% (8/782) of cases (2/44 melanoma, 1/11 GIST, 1/39 cholangiocarcinoma, 1/247 colorectal, 1/14 oesophagus, 1/97 breast, 1/31 prostate). Mean time for seeding was 208 days (range 43-469 d); mean post-biopsy survival time was 495 days in the seeding and 349 days in the non-seeding group.

Conclusions: Percutaneous biopsy of suspected liver metastases is a safe and effective diagnostic technique with a low rate of post-procedural complications and a high rate of diagnostic adequacy of samples gathered. Position of guide needle in coaxial technique affects neither success of biopsy nor complication rate.

Abstract No. 691

Safety and diagnostic utility of percutaneous trans caval retroperitoneal biopsies
M. Pohlen1, J. Kuban2, A. Murphy1, R. Sheth3, S. McRae3, J. Ahrar3, A. Tam3, S. Gupta3, 1Baylor College of Medicine, Houston, TX; 2UT/MD Anderson, Houston, TX; 3MD Anderson Cancer Center, Houston, TX

Purpose: Percutaneous biopsy of retroperitoneal lesions via a transcaval approach has historically not been a preferred means of access secondary to concern for bleeding complications. The purpose of this study is to examine the safety and diagnostic adequacy of transcaval biopsies.

Materials: 31 patients with clinical follow up underwent percutaneous transcaval biopsy of a retroperitoneal node using coaxial technique. Biopsies were performed with 22G fine needle aspiration (31/31) with or without additional 20G core biopsy (5/31). Clinical, imaging, and laboratory variables were analyzed, including position of guide needle with respect to the cava.

Results: Technical success was achieved in 100% of cases. Biopsies were diagnostic in 25/31 patients (80%). 24 (77%) cases were performed with FNA only and with pre-caval guide position, and 7 (23%) were performed with post-caval guide position (through both walls of the cava). There was no significant difference between pre and post-caval guide positions on rate of diagnostic success (p=0.9) or change in hemoglobin levels (p=1.0). Flow cytometry was able to be performed in 4/7 (57%) cases in patients with history of non-Hodgkin's Lymphoma. There was 1 complication (3%) of post-biopsy retroperitoneal hemorrhage without hemodynamic changes in the pre-caval group which was managed conservatively.

Conclusions: Percutaneous transcaval coaxial biopsy of retroperitoneal lesions is a safe and effective diagnostic technique with a low rate of post-procedural complications and a high rate of diagnostic adequacy of samples gathered. Position of guide needle in coaxial technique affects neither success of biopsy nor complication rate.

Abstract No. 692

The efficacy of cone beam CT-based liver perfusion imaging for tumor vascularity and treatment response evaluation after TACE for HCC
S. Choi1, K. Kim2, M. Kim1; 1College of Medicine, Ewha Womans University, Seoul, Republic of Korea; 2St. Vincent’s Hospital, College of Medicine, The Catholic University of Korea, Suwon, Republic of Korea

Purpose: We evaluated the efficacy of the assessment of tumor vascularity and immediate tumor response evaluation using cone-beam computed tomography (CBCT)-based liver perfusion imaging in TACE.

Materials: From August to June 2016, 37 patients with 61 tumor lesions who underwent CBCT with post-processing software via TACE for HCC treatment were enrolled. Two reviewers evaluated the confidence level of viable tumors in each angiography, CBCT, and a CBCT-based liver perfusion map and lipiodol CT after TACE using a four-point scale. Mean tumor blood volume (BV) was measured on perfusion image with drawing ROI along tumor margin before and after TACE. The treatment response to TACE was recorded according to the modified RECIST on the first follow-up imaging study after TACE. Prediction power was evaluated using multiple logistic regression, which was adjusted with age, sex, and tumor size.

Results: Mean tumor BV before and after TACE was $-0.12 \pm 33.01$ and $-12.78 \pm 23.45$ ml/L. CBCT, CBCT-based liver perfusion map, lipiodol CT and mean tumor BV were significant (each $p<0.0005$, $p<0.0001$, $p=0.0004$ and $p<0.0001$) in predicting viable tumor but angiography was not ($p=0.9842$). C-statistics of mean tumor BV was highest as 0.884 and visual scoring of
Transarterial chemoembolization treatment of liver-dominant metastatic leiomyosarcoma

H. Krzyston1, B. Morse2, A. Rishi2, G. El-Haddad2, J. Smith2, M. Druta2, B. Kis2; 1USF Morsani College of Medicine, Tampa, FL; 2Moffitt Cancer Center, Tampa, FL.

Purpose: To determine the safety and efficacy of trans arterial chemoembolization (TACE) in patients with metastatic leiomyosarcoma to the liver who are not candidates for surgical resection.

Materials: This is a single institution retrospective study of unresectable metastatic leiomyosarcoma to the liver treated with TACE using doxorubicin-loaded drug-eluting LC beads. Retrospective review of electronic medical records and imaging studies were performed to evaluate clinical and biochemical toxicities and overall survival. Radiological response of liver metastasis was evaluated in cross-sectional imaging and was categorized according to the modified Response Evaluation Criteria in Solid Tumors (mRECIST) and the European Association for study of the Liver (EASL).

Results: A total of 9 patients were identified (6 males, 3 females) with an average age of 71 years. 6 patients received bilobar treatment and 3 received unilobar treatment. 5 patients underwent 1 TACE procedure, 3 underwent 2 procedures, and 1 patient underwent 6 procedures. The average dose was 41.63 mg of doxorubicin delivered per treatment via either 70-150 micron or 100-300 micron DEB. Mean survival from diagnosis was 71.24 months (95% CI 43.7-98.75) and median overall survival from diagnosis was 47 months. The VEA showed a good correlation with REA. The mean cross-sectional areas in the coronal of VEA and REA were 2392 ± 1028 mm² and 2451 ± 1164 mm². The ICC between VEA and REA was 0.914 (95% CI: 0.816, 0.977). The mean cross-sectional areas in the sagittal of VEA and REA were 2477 ± 782 mm² and 2445 ± 1031 mm². The ICC between VEA and REA was 0.874 (95% CI: 0.666, 0.956). Thus, the overall agreement between VEA and REA was almost perfect reliability.

Conclusions: The VEA showed a good correlation with REA. The VLPP using existing 3-D workstation (Synapse Vincent, Fuji Film Co., Ltd.) and liver analysis software might be useful for evaluating embolization area in cTACE.

Transradial versus transfemoral access for DEB-TACE: analysis of radiographic parameters

V. Gupta1, A. Al Khalifah2, N. Akhter3; 1University of Maryland, Baltimore, MD; 2University of Maryland Medical Center, Elkridge, MD; 3University of Maryland Medical Center, Baltimore, MD.

Purpose: Drug Eluting Bead Transarterial Chemoembolization (DEB-TACE) is an important treatment modality for liver directed therapy of malignancy. Traditionally performed via transfemoral (TF) arterial access, there is growing interest in transradial (TR) approach. Prior research in body and cardiac intervention has CBCT-based liver perfusion map was secondarily high (0.855). C-statistics of CBCT and lipiodol CT was each 0.787, and 0.827. Conclusions: A CBCT-based liver perfusion map provided reliable images to predict viable tumor by qualitative analysis with visual scoring and quantitative analysis with mean tumor blood volume as a perfusion factor after TACE.
demonstrated TR access to have faster recovery, decreased pain and decreased cost. This study compares radiographic parameters for TR versus TF access for DEB-TACE.

**Materials:** A retrospective review of all DEB-TACE performed at a tertiary referral center between June 2015 and August 2017 was performed. In total, 109 TACE were performed by subspecialty trained interventional radiologists. 53 (49%) TR and 56 (51%) TF approach. No patients were excluded, and each patient received one procedure during the study interval. Radiation dose (peak skin dose), total procedure time, fluoroscopic time and intraarterial contrast volume were recorded. Variables were evaluated using student's t test for statistical difference between the two groups.

**Results:** The two study groups had similar demographic and clinical characteristics (age, gender, malignancy). Both groups demonstrated 100% technical success rate without immediate complication. Radiation dose was not statistically significant between TR versus TF (1386 & 1382 milliGy respectively, p < 0.98). Total fluoroscopic time was not statistically significant between TR versus TF (27 & 25 minutes, respectively, p < .33). Administered contrast volume was higher for TR versus TF approach (177 & 113 ml respectively, p < .00001). Total procedure time was also higher for TR versus TF approach (123 & 106 minutes, respectively, p < .05).

**Conclusions:** Our findings demonstrate no difference in radiation exposure or fluoroscopy time in patients undergoing DEB-TACE via TR or TF approaches. Given similar outcomes and known advantages, TR approach provides an appealing alternative to improve patient recovery without increasing radiation dose. Further research is needed to explore higher procedure time and contrast volume seen with TR approach.

---

**Abstract No. 696**

**Pre-SIRT bevacizumab does not affect outcomes in patients with non-colorectal cancer metastatic to the liver**

D. Xu¹, S. Haider², M. Chervonski³, R. Widemon⁴, S. Reis⁵; ¹Columbia New York Presbyterian Medical Center, New York, NY; ²NewYork Presbyterian / Columbia University Medical Center, New York, NY; ³Columbia University Medical Center, New York, NY; ⁴N/A, New York, NY; ⁵Columbia University, New York, NY

**Purpose:** To evaluate treatment response and overall survival of patients with non-colorectal malignancies metastatic to liver for which bevacizumab was administered for either indicated or off-label trial use. 27 patients fit the inclusion criteria (mean age 58 years, 9 male, 2 adenocarcinical, 10 breast, 1 fallopian, 3 lung, 10 pancreatic, and 1 uterine cancer). 6 patients were treated with bevacizumab prior to SIRT. 14 patients underwent 1 SIRT session, 9 patients underwent 2, and 4 underwent 3. 15 patients had SIRT to both liver lobes, while 10 had SIRT to the right liver lobe and 2 had SIRT to the left liver lobe. Modified RECIST criteria after SIRT was used to determine treatment response. 25 patients had follow up imaging. Survival analysis was performed using a Kaplan-Meier model. A Cox regression hazards model was used for comparison of bevacizumab to other prognostic factors.

**Results:** Response to treatment is predictive of improved overall survival in our study (mean 447 days vs 869 days, P=0.05, HR=10.9). Bevacizumab prior to Y90 therapy was not a significant factor associated with increased survival (mean 258 days vs 744 days, P=0.25, HR=1.64). Bevacizumab prior to SIRT was not a significant factor associated with treatment response (P=0.196). Total bilirubin prior to SIRT was a nonsignificant predictor of reduced survival (P=0.087, HR=5.399). Past lifetime alcohol use was a significant predictor of reduced survival (P=0.041, HR=18.781).

**Conclusions:** Imaging response post-SIRT is significantly predictive of overall survival for patients with non-colorectal cancer metastatic to the liver. However, bevacizumab prior to SIRT is neither predictive of overall survival nor imaging response. Increased total bilirubin prior to SIRT was a nonsignificant predictor of reduced overall survival. Past lifetime alcohol use was a significant predictor of decreased overall survival.

---

**Abstract No. 697**

**New York State demographic trends in radioembolization**

M. Finkelstein¹, D. Kestenbaum², E. Kim³, F. Nowakowski⁴, R. Patel⁴, V. Bishay⁴, M. Ranade², R. Lookstein⁴, A. Fischman⁴; ¹Icahn School of Medicine at Mount Sinai Hospital, New York City, NY; ²Mount Sinai Hospital, New York, NY; ³Mount Sinai Medical Center, New York, NY; ⁴Icahn School of Medicine at Mount Sinai Hospital, New York, NY; ⁵Icahn School of Medicine at Mount Sinai, New York, NY

**Purpose:** Radioembolization (RE) is increasingly being performed in the treatment of hepatocellular carcinoma and liver metastases. This study examines the demographic trends associated with RE performed in New York State.

**Materials:** The New York Statewide Planning and Research Cooperative System, which covers all admissions and ambulatory care encounters in New York State, was queried over the period from 2006 to 2014 for encounters involving patients who were diagnosed with a hepatic tumor and where RE was performed. Encounters were divided by year into 3 categories: 2006-2008, 2009-2011, and 2012-2014. Patient demographic information was supplemented by facility information from the American Hospital Association was compared using Mann–Whitney U and chi-square tests.

**Results:** A total of 2,211 encounters involving RE were identified, occurring at a total of 22 facilities in New York State. The number of facilities performing RE increased from 3 in the earliest time period to 22 in the latest. Similarly, the number of RE’s increased from 225 to 1,516, representing a 556% increase. The proportion of African-Americans who underwent RE increased from 5% to 14% (p<0.01). The proportion of RE’s performed at major teaching hospitals decreased from 100% to 80% (p<0.01).

**Conclusions:** Over the period from 2006 to 2014, the quantity of RE’s performed has increased drastically. During this same period, there has been a significant expansion in the proportion of REs performed by non-major academic centers. This expansion has been paralleled by an increase in the proportion of African-Americans undergoing RE.
Percutaneous embosclerosis for management of biliary leaks
S. Bhanot¹, S. Madassery², Z. Bhatti³, B. Arslan⁴; ¹George Washington University School of Medicine and Health Sciences, Washington, DC; ²Rush University Medical Center, Rush Oak Park Hospital, Glenview, IL; ³N/A, Houston, TX; ⁴Rush University Medical Center, Chicago, IL

Purpose: Management of biliary leaks are complex and usually require prolonged diversion using drainage catheters. For the patient, and treating interventionalists/surgeons, this is a very frustrating process with uncertain endpoint. For refractory biliary leak cases, we evaluated the potential use of biliary leak embolization using the liquid embolic Onyx® (Covidean, Minneapolis, Minnesota), shortly after initial diversion.

Materials:
Three cases in which patients had bile duct injuries intervened upon using liquid embolization were reviewed. The cases were evaluated for: time to embolization attempt after initial diversion, findings on subsequent follow-up cholangiogram, and findings on outpatient patient evaluation after all catheters were removed.

Results: 3 cases were reviewed from two institutions, with 1 biliary leak secondary to hepatic hemangioma percutaneous ablation, 1 secondary to a gunshot wound complication, and 1 which was secondary to was due gastric cancer resection. All three cases involved initial internal-external biliary drainage catheter diversion, and in one case, a biloma drain was also placed. On subsequent cholangiograms (range: 2 days-2 weeks later), each case had a single attempt at microcatheter cannulation of biliary tract leak, and embolization with liquid Onyx®. In 3 of 3 cases (100%), there was complete bile leak cessation at the time of follow up cholangiogram, resulting in drainage catheter removal, and no complications or recurrence on clinical follow up.

Conclusions: Biliary leak embolization with Onyx® is feasible and safe for early treatment of biliary leaks early after catheter based diversion.

Placement of biliary stent for triple hepatic duct drainage in hilar malignancy
M. Song¹, T. Seo¹, S. Park², Y. Kim³, S. Cho³, E. Jung⁴; ¹Korea University Guro Hospital, Seoul, Republic of Korea; ²Korea University Ansan Hospital, Ansan, Korea

Results: 3 cases were reviewed from two institutions, with 1 biliary leak secondary to hepatic hemangioma percutaneous ablation, 1 secondary to a gunshot wound complication, and 1 which was secondary to was due gastric cancer resection. All three cases involved initial internal-external biliary drainage catheter diversion, and in one case, a biloma drain was also placed. On subsequent cholangiograms (range: 2 days-2 weeks later), each case had a single attempt at microcatheter cannulation of biliary tract leak, and embolization with liquid Onyx®. In 3 of 3 cases (100%), there was complete bile leak cessation at the time of follow up cholangiogram, resulting in drainage catheter removal, and no complications or recurrence on clinical follow up.

Conclusions: Biliary leak embolization with Onyx® is feasible and safe for early treatment of biliary leaks early after catheter based diversion.
Republic of Korea; 3Korea University Anam Hospital, Seoul, Republic of Korea; 4Nowon Eulji Medical Center, Seoul, Republic of Korea

**Purpose:** To evaluate the technical feasibility and clinical efficacy of placement of biliary stent for triple hepatic duct drainage in malignant hilar biliary obstruction.

**Materials:** From January 2013 to February 2017, 18 consecutive patients with hilar malignancy underwent percutaneous placement of a crisscross-configured closed cell stent for palliative treatment. The Bismuth classification was type IV in all patients. Causes of obstruction were cholangiocarcinoma (n=10), metastasis of stomach cancer (n=4), metastasis of GB cancer (n=3), and metastasis of colon cancer (n=1). Technical and clinical success, cumulative patient survival, and stent patency were evaluated.

**Results:** Stent placement was technically successful in all patients and was clinically successful in 17 patients. Numbers of percutaneous biliary drainage (PTBD) were 2 in all patients. Sites of PTBD were S3 with S5 (n=2), S3 with S6 (n=10), and S5 with S6 (n=6). Initial serum bilirubin level ranged from 1.7 to 15.1 mg/dl (mean 5.1 mg/dl). Serum bilirubin level decreased significantly 1 week after placement (range 1.2-9.0 mg/dl, mean 2.9 mg/dl) and 1 month (range 0.35-5.77 mg/dl, mean 1.6 mg/dl), respectively after placement of biliary stent (p<0.001). Mean survival time was 187 days (range 2-705) and mean primary stent patency was 134 days (range 2-385).

**Conclusions:** Percutaneous placement of crisscross-configured biliary stent seems to be technically feasible and clinically effective for triple hepatic duct drainage in hilar malignancy.

---

**Abstract No. 700**

**Which method of biliary drainage results in the most rapid decline in bilirubin levels, primary stent or drain placement?**

S. Rice1, W. Alago2; 1Memorial Sloan-Kettering Cancer Center, Forest Hills, NY; 2Memorial Sloan-Kettering Cancer Center, New York, NY

**Purpose:** Compare the rate of decline in the serum total bilirubin levels post biliary drainage with placement of a primary stent or drainage catheter.

**Materials:** Medical record review of all primary biliary stents (PBS) and biliary catheter drainage (BD) placements from January 2016 till March of 2017 at a single institution identified 81 PBS and 118 BD procedure performed in 180 patients (107 males; median age 60.66 +/- 13.33, 73 females; median age 60.69 +/- 14.43, range 8-88). Procedures performed for cholangitis and for post procedure biliary complications were excluded. 70 PBS and 83 BD met these criteria. Procedure type and decision for drainage of the right or left biliary system was under the discretion of the primary operator. Available total bilirubin (t-bili) levels were collected for patients pre-procedure (n=153), post procedure day (POD) one (n=146), POD two (n=102), POD seven (day 9 +/- 3.2) (n=132), and POD 30 (day 31.8 +/- 8.8) (n=113).

**Results:** Successful drainages with a decrease in the t-bili noted at all time points; PBS (n=49) vs BD (n=52) POD 1 (23.78 +/- 16.3 vs 25.43 +/- 16.8 p=0.62), PBS vs BD POD 2 (34.87 +/- 16.96 vs 43.02 +/- 16.57 p=0.06), PBS vs BD POD 7 (56.83 +/- 20.2 vs 57.41 +/- 19.88 p=0.88), PBS vs BD POD 30 (78.53 +/- 12.48 vs 71.61 +/- 21.41 p=0.07). All drainages including procedure failures; PBS vs BD POD 1 (14.39 +/- 27.49 vs 12.69 +/- 30.68 p=0.73), PBS vs BD POD 2 (23.39 +/- 28.1 vs 21.98 +/- 59.99 p=0.90), PBS vs BD POD 7 (45.62 +/- 36.55 vs 36.81 +/- 44.94 p=0.21), PBS vs BD POD 30 (69.29 +/- 31.18 vs 47.93 +/- 62.49 p=0.02).

**Conclusions:** The rate of t-bili reduction is more rapid in PBS during the first 30 days after placement. At 30 days PBS has decreased the t-bili levels in all patients by 69.29, this is statistically significant compared to the decrease in t-bili with BD (47.93) p=0.02. BD tend to fail more often in lowering the t-bili. When initially successful, BD appears to decrease the t-bili at a slightly more rapid rate then PBS. At 30 days this appears to reverse with PBS again providing the greatest percent reduction.

---

**Abstract No. 701**

**Percutaneous radiologic gastrostomy/ gastrojejunostomy placement without nasogastric access: US-guided gastric puncture technique and evaluation of feasibility and safety**

J. Yi1, H. Hong2, M. Kim3, E. Chung1; 1Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, Seoul, Seoul; 2Kangbuk Samsug Hospital, Sungkyunkwan University School of Medicine, Seoul, Seoul

**Purpose:** Gastrostomy/gastrojejunostomy needs for enteral feeding in patients with high-grade narrowing or obstruction by variable cause. But stenosis or obstruction of upper GI tract itself makes impossible to pass the endoscopy or NG tube placement for conventional gastrostomy/gastrojejunostomy. We introduce the new technique, that is US-guided gastric puncture without NG tube placement for stomach inflation and evaluate the feasibility, safety, technical/clinical success and complication of that technique.

**Materials:** From January 2013 to April 2014, 11 patients with high-grade stenosis or obstruction of upper GI tract who underwent percutaneous radiologic gastrostomy or gastrojejunostomy without NG tube placement were enrolled in this study. USG guided gastric puncture was performed with 21G Chiba needle, normal saline is infused in the stomach, alternative for air insufflation by NG tube. After then US-guided puncture for gastroscopy and tube insertion was performed. Next step is same with conventional percutaneous radiologic gastrostomy/ gastrojejunostomy.

**Results:** We successfully puncture in all patients with two attempts for one patient due to slipping out of the Chiba needle from stomach to the peritoneal cavity in the process of saline infusion. All patients were able to do enteral feeding through gastrostomy/ gastrojejunostomy tube. There is no minor or major complication after the procedure.

**Conclusions:** US-guided gastric puncture for percutaneous radiologic gastrostomy or gastrojejunostomy is feasible and safe technique.
Abstract No. 702

Hemorrhage risk in cirrhotic patients with portal hypertension and upper abdominal varices undergoing radiologic guided gastrostomy or gastrojejunostomy tube placement

C. Ziegler1, C. Kim2, J. Ronald2; 1Duke University, Durham, NC; 2Duke University Medical Center, Durham, NC

**Purpose:** Gastric varices are considered a relative contraindication to radiologic guided gastrostomy or gastrojejunostomy (G/GJ) tube placement. Although traversal of a varix during tube placement may result in gastrointestinal (GI) bleeding, a snug gastropexy may tamponade a punctured varix. Conversely, patients without varices but with sequelae of portal hypertension such as portal hypertensive gastropathy may be at high risk for post-procedure hemorrhage. The purpose of this study was to quantify the hemorrhage risk following G/GJ tube placement in cirrhotic patients with portal hypertension and upper abdominal varices.

**Materials:** In this retrospective study 31 patients (N=23 males; mean age=51) with Child Pugh A (N=6), B (N=22), or C (N=3) cirrhosis (mean MELD=14) underwent radiologic guided G/GJ tube placement from 2006 to 2016. All procedures were technically successful with placement of 18 French balloon retained G/GJ tubes via a transabdominal approach. Twelve patients had esophageal (N=11) and/or gastric varices (N=8) documented by endoscopy (N=6) and/or imaging (N=10). Twenty-two patients had portal hypertension as evidenced by ascites (N=19), splenomegaly (N=12), and/or varices (N=12). The medical record was reviewed to determine postprocedure outcomes which were compared using Fisher's exact test and T-tests.

**Results:** There were no episodes of documented GI or intra-portal bleeding within 30 days postprocedure. Two patients underwent transfusion, one with varices and one without (p=1.0). The mean change in hematocrit following G/GJ tube placement was 0.31 in patients with varices and -0.95 in patients without varices (p=0.31). Portal hypertension was not a predictor of need for transfusion (p=0.50) or drop in postprocedure hematocrit (p=0.74). There were 4 deaths within 30 days of the procedure all unrelated to GI bleeding.

**Conclusions:** Among cirrhotic patients undergoing G/GJ tube placement, including those with portal hypertension and upper abdominal varices, the risk of postprocedure GI bleeding was low. Nonetheless, the 13% 30-day mortality rate indicates that need for enteral access portends a poor prognosis in cirrhotic patients.

---

Abstract No. 704

Single-session 99.5% ethanol sclerotherapy for simple renal cysts: comparison of 40- and 120-minute retention techniques

J. Kim1, U. Jeon1, J. Jang1; 1Pusan National University Yangsan Hospital, Yangsan, Gyeongnam

**Purpose:** To compare the results of 40- and 120-minute ethanol sclerotherapies which were performed in a single session for the management of simple renal cysts.

**Materials:** We retrospectively reviewed 63 renal cysts in 62 patients treated by single-session percutaneous ethanol sclerotherapy. Thirty-two cysts in 31 patients underwent 40-minute sclerotherapy (group A) and 31 cysts in 31 patients underwent 120-minute retention technique (group B). Under ultrasonographic and fluoroscopic guidance, the cystic fluid was completely aspirated and 50% of the aspirated volume replaced with 99.5% ethanol (maximum, 100 mL). Follow-up of the patients were performed with ultrasonography or computed tomography (CT) at 3 months after sclerotherapy.

**Results:** Overall, technical success rates were 100% in both two groups. Eighteen patients (28.6%) were symptomatic (flank pain or discomfort). Indications of the other patients were large cyst (>5 cm; 46%) and increment of the diameter on serial studies (25.4%). There was no significant difference between the two groups in terms of age (62.22 vs. 64.48 years), cyst diameter (8.43 vs. 8.14 cm), volume of aspirated fluid (230.06 vs. 250.16 mL),
Role of contrast-enhanced ultrasound guidance in core-needle biopsy for diagnosis of cervical tuberculous mycobacterial lymphadenitis

D. Zhao1, G. Yang2; 1Hangzhou Red Cross Hospital, Tuberculosis Diagnostic and Treatment Center of Zhejiang Province, China; Hangzhou City, Zhejiang Province; 2Hangzhou Red Cross Hospital, Tuberculosis Diagnostic and Treatment Center of Zhejiang Province, China, Hangzhou, Zhejiang

Purpose: To investigate the role of core-needle biopsy (CNB) guided by contrast-enhanced ultrasound (CEUS) played in the diagnosis for cervical tuberculous mycobacterial lymphadenitidis (TML).

Materials: One hundred and seventy-one lymph nodes in 171 patients with pathological confirmation of TML were retrospectively enrolled. All had undergone CNB before the final surgery. The patients were assigned to either conventional ultrasound (US) guided CNB group (n=87) or CEUS guided CNB group (n=84). The comparison of two groups on diagnostic efficacy in terms of sensitivity was statistically made. Subgroup analyses on lymph node size were performed furthermore.

Results: Among the 171 patients, one hundred and forty-one patients were directly diagnosed to be TML in CNB, which were consisted by 77 patients in CEUS-guided CNB group and 64 patients in conventional US guided CNB group. The sensitivities were 91.7% (77/84) and 73.6% (64/87), respectively (p<0.01). As to subgroup analyses, differences among sensitivities caused by the two guiding methods were significant in medium size group (i.e., diameter was 2.0-3.0cm) and large size group (i.e., diameter was larger than 3.0cm), 93.1% for CEUS group vs. 74.2% for conventional US group (p<0.05) and 85.7% for CEUS group vs. 57.1% for conventional US group (p<0.01), respectively. However, no significant difference was found in small size group (i.e., diameter was smaller than 2.0 cm) (96.3% for CEUS group vs. 92.9% for conventional US group, p=0.57).

Conclusions: Comparing with conventional US guided CNB, further benefits could be gained through CEUS guided CNB in TML diagnosis, especially for those whose diameter was larger than 2.0 cm.

Role of Contrast-enhanced Ultrasound Guidance in Core-Needle Biopsy For Diagnosis of Cervical Tuberculous Mycobacterial Lymphadenitis

<table>
<thead>
<tr>
<th>Size</th>
<th>US guided CNB</th>
<th>CEUS guided CNB</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2.0 cm</td>
<td>92.9% (26/28)</td>
<td>96.3% (26/27)</td>
<td>0.574</td>
</tr>
<tr>
<td>2.0-3.0 cm</td>
<td>74.2% (22/31)</td>
<td>93.1% (27/29)</td>
<td>0.027*</td>
</tr>
<tr>
<td>&gt;3.0 cm</td>
<td>57.1% (16/28)</td>
<td>85.7% (24/28)</td>
<td>0.009*</td>
</tr>
<tr>
<td>Total</td>
<td>73.6% (64/87)</td>
<td>91.7% (77/84)</td>
<td>0.002*</td>
</tr>
</tbody>
</table>

Abstract No. 707

A retrospective, descriptive study of hemorrhagic complications associated with fluoroscopy-guided lumbar puncture: a single-institution experience

R. Ruttiman1, E. Siddiqui2, G. Dubel3, S. Ahn4; 1Brown University, Providence, RI; 2Rhode Island Hospital, Brown University, Providence, RI; 3Alpert School of Medicine, Brown University, Providence, RI; 4Brown University, Providence, RI
Medicine of Brown University, Providence, RI; 4Alpert Medical School of Brown University, Rumford, RI

Purpose: Multiple case reports have presented spinal hematoma and other hemorrhagic complications associated with lumbar puncture (LP). However, the rate of hemorrhagic complications in the setting of fluoroscopy-guided LP remains ill-defined. The purpose of this study was to assess the rate of hemorrhagic complications after fluoroscopy-guided LP overall and in patients on aspirin and/or clopidogrel at a single institution.

Materials: A retrospective review was performed for patients receiving fluoroscopy-guided lumbar puncture by interventional radiology between March 2015 and August 2017. Patient demographics, aspirin/clopidogrel status, pre-procedure labs (INR, PTT and platelets) and hemorrhagic complications were documented. Hemorrhagic complications assessed were defined as post-LP pRBC transfusion, epidural hematoma, increase in level care and 30-day LP related death.

Results: Eight hundred and ninety-six patients with a mean age of 53.9 (±19.6) underwent 1155 LPs, 908 (78.6%) of which were performed on patients not on aspirin or clopidogrel. 223 (19.3%), 9 (0.8%), and 15 (1.3%) LPs were performed on patients on aspirin, clopidogrel and aspirin and clopidogrel, respectively. The majority of available pre-procedure INR, PTT and platelet findings fell within normal ranges. Of patients on aspirin, aspirin was not withheld prior to LP in 219 (98.2%) cases. Clopidogrel was withheld prior LP in all cases involving patients on clopidogrel alone. Regarding LPs for patients on both aspirin and clopidogrel, aspirin was withheld in 4 (26.7%) cases, while clopidogrel was withheld 14 (93.4%) cases. In 1155 LPs, there were no hemorrhagic complications.

Conclusions: Hemorrhagic complications after fluoroscopic guided LP is very rare overall and also in patients on anti-platelet therapy with aspirin, clopidogrel, and both. This may indicate that delaying fluoroscopic LP due to aspirin or clopidogrel may be deleterious as it may delay necessary diagnosis and treatment.

Abstract No. 708

The utility of percutaneous image guided tumor ablation in the treatment of solid and vascular pediatric and young adult tumors

T. Brown1, H. Hasham2, N. Maitra1, A. Robinson3, B. Reading4, B. Cully5, S Bolger Theut6, K. Chastain3, R. Hendrickson3, D. Rivard6; 1University of Missouri - Kansas City, Kansas City, MO; 2University of Kansas, Kansas City, KS; 3The Children's Mercy Hospital, Kansas City, MO; 4N/A, United States; 5N/A, Kansas City, MO; 6Children's Mercy Hospital, Kansas City, MO

Purpose: Percutaneous image guided tumor ablation (PTA) is a medical technique that utilizes chemical or thermal energy to treat a variety of lesions. The development of minimally invasive procedures like PTA for the treatment of solid and vascular tumors has been studied extensively in adults and found to have increased survival, decreased morbidity, and improved quality of life. This innovation in adult interventional radiology provides the template for new minimally invasive therapies in the pediatric population. The goal of this study is to evaluate improvement in patient quality of life, pre- and post-procedure pain, and imaging response to treatment. Our study aims to lay the groundwork for providing minimally invasive IR procedures/techniques to pediatric oncologists and their patients earlier in the treatment process.

Materials: We conducted a single site retrospective cohort study evaluating patients 0-21, whom underwent PTA from January 2008 to July 2017. Clinical information about the patients underlying condition, surgical and treatment history, pre- and post-pain scales and imaging data were evaluated.

Results: A total of 23 PTA procedures were performed on 21 pediatric patients at our institution. Majority of patients were female (n=11, 52.3%) and the average age was 13.9 years. 18 (85.6%) had malignant disease and 3 (14%) had low-flow vascular malformations. Almost all of the cases were solid tumors (n=18, 85.7%) and over half of were treated with RFA (n=12, 52.2%), three (13%) with MWA and the remaining 34.8% (n=8) were treated with cryoablation. Nearly all patients were undergoing PTA for pain control (n=15, 71.4%) and/or refractory to prior gold-standard therapies (n=17, 80.9%). 10 (47%) of patients reported moderate pain and 2 (.09%) severe pain pre-procedure. During follow-up clinic visits, three patients (14%) reported mild pain at 1-month, 2 (.09%) at 6-months and 1 (.04%) at 1-year post-PTA.

Conclusions: The use of PTA is safe for pediatric patients with vascular or solid tumors refractory or not amendable to traditional therapies with a majority experiencing decreased pain and improved quality of life post procedure.

Abstract No. 709

Quality improvement in interventional radiology: techniques to improve patient satisfaction

K. Welch1, J. Aguilar1, J. Ste. Marie1, K. Scheuerlein1, P. Patel2, R. Hieb2, S. Tutton2, W. Rilling2, S. White2, E. Hohenwarter2; 1Froedtert Memorial Lutheran Hospital, Milwaukee, WI; 2Medical College of Wisconsin, Milwaukee, WI

Purpose: Managing a patient's peri-procedural pain is vital to a positive patient experience in Interventional Radiology (IR). Patient satisfaction scores are one way to track this. At our institution, patient satisfaction (Avatar Solutions, Chicago, IL) scores from 2012 to 2013 were found to be below our goal in pain management. The purpose of this study was to implement strategies to increase our pain-related patient satisfaction scores.

Materials: This project was part of a quality improvement project, and therefore exempt by the Institutional Review Board. Four new processes were implemented to increase pain-related patient satisfaction scores. First, Lidocaine Hydrochloride buffered with 8.4% Sodium Bicarbonate was utilized for local anesthesia for all procedures. Second, scripting cards which reflected the survey language were given to providers. In addition, signs were posted in all pre-procedural rooms asking patients to report pain they were experiencing. Finally, patient discharge instructions were updated to include survey-specific language regarding post-procedure pain management. Between initial patient satisfaction scores in July 2013 and March 2014, patients were anonymously surveyed and asked the following questions: "My request for pain control was
responded to quickly” and “I was taught how my pain would be managed.”

**Results:** Satisfaction scores improved by 8.46% (82.69% to 91.15%) and 7.09% (80.88% to 87.97%) for the two questions, which translated into an increase to our division’s Top Box Score Customer Service Score.

**Conclusions:** Incorporating buffered local anesthetic, specific language, signage, and updating discharge instructions into our practice have proven effective at increasing our patient satisfaction scores in regards to pain management.

**Abstract No. 710**

Evaluation of the effect of prior imaging on procedure time for mesenteric angiograms performed for acute lower GI bleed at a single institution

A. Al Khalifah¹, S. Osei-Bonsu², S. Lowe³, V. Etezadi⁴; ¹University of Maryland Medical Center, Elkridge, MD; ²University of Maryland Medical Center, Baltimore, MD; ³N/A, Ellicott City, MD; ⁴Department of Radiology University of Maryland, Baltimore, MD

**Purpose:** To evaluate the effect of prior imaging on procedure time for mesenteric angiograms performed for acute lower GI bleed at a single institution.

**Materials:** This retrospective study reviewed 82 patients who underwent mesenteric angiograms performed for acute lower GI bleed in our institution between 2011 and 2016. 34 patients with positive mesenteric angiograms were divided into 4 groups based on prior imaging. ANOVA sings factor was performed to compare the mean procedure time between groups.

**Results:** A total of 34 patients had positive mesenteric angiograms (34/82). Of these, 7 had a prior positive CTA, 11 had prior positive RBC scan, 5 had either a negative prior CTA or RBC scan and 11 had no prior diagnostic imaging. The mean procedure times were 77.8 min for the positive CTA group, 108 min for positive RBC group, 91 min for the group with negative imaging and 112 min for that with no prior imaging. Though the group with the positive CTA had the shortest mean procedure time, the difference was not statistically significant compared to the other groups (p-value 0.1).

**Conclusions:** Procedural times for mesenteric angiograms in patients with prior positive imaging was shown not to be significantly different from those with negative or no prior imaging.

**Abstract No. 711**

Safety of transjugular liver biopsy in patients with recent liver transplant

Y. Kim¹, A. Price², N. Fidelman¹; ¹University of California San Francisco, San Francisco, CA; ²Department of Radiology and Biomedical Imaging, San Francisco, CA

**Purpose:** To determine the efficacy and safety of transjugular liver biopsy (TJLB) in patients who received a liver transplant less than 30 days prior to the biopsy procedure.

**Materials:** A single-center retrospective review identified 306 consecutive TJLB in 190 adult liver transplant recipients performed between January 2001 and June 2017. Data on patient demographics, surgical hepatic vein anastomosis, number of transjugular biopsy passes, tissue adequacy, complications, and fluoroscopy time were recorded. The rates of post-procedure complications was compared for procedures performed ≤ 30 days and > 30 days following transplantation.

**Results:** A total of 39 TJLB procedures performed within 30 days of liver transplantation. Technical success was achieved in 97.4% (38 of 39) of the biopsies. TJLB failed in one patient due to a thrombosed SVC. Bi-caval anastomoses were present in 13 patients (14 biopsies), and piggyback anastomoses were present in 24 patients (25 biopsies). Complications developed after four (10.3%) TJLB procedures performed ≤ 30 days following liver transplantation and after four (1.5%) TJLB procedures performed > 30 days after liver transplantation. The rate of complications was significantly higher for TJLB performed ≤ 30 days following liver transplantation (p = 0.002). Of the 4 complications reported in the short interval group, 2 were intrahepatic hematomas and 1 was a subcapsular hepatic hematoma, and 1 was an intra-peritoneal bleed. All hemorrhagic complications were self-limiting.

**Conclusions:** TJLBs between 7 to 30 days after a liver transplant have a higher complication rate compared to TJLBs performed > 30 days after. However, the procedure still remains a relatively safe and efficacious option for diagnosis of liver failure in patients that require them.

**Abstract No. 712**

Safety and efficacy for primary portal vein stenting after liver transplantation: comparison of three different approaches

J. Jang¹, U. Jeon¹, J. Kim; ¹Pusan National University Yangsan Hospital, Yangsan, Republic of Korea

**Purpose:** To evaluate the safety and efficacy of primary portal vein (PV) via percutaneous transsplenic, transhepatic and intra-operative transmesenteric access in liver transplant recipients.

**Materials:** From May 2010 to August 2017, 364 liver transplantations were performed in 359 patients. Of them, 17 patients with primary PV stenting and following balloon angioplasty from PV stenosis via percutaneous transsplenic (TH group, n = 7), transsplenic (TS group, n = 5) and intraoperative transmesenteric (TM group, n = 5) access were enrolled. 11 patients were underwent living donor liver transplantation (LDLT) and 6 patients deceased donor liver transplantation (DDLT) or 17 patients. Complication and patency of the stents were compared with each groups, retrospectively.

**Results:** PV stenting were successfully achieved in all patients. Mean interval between surgery and stenting was 75 days (15-125 days) in TS group and 170 days (22-442 days) in TH group. In case of TM group, 2 patients underwent PV stent placement simultaneously with LT, and 3 patients underwent 1-5 days after LT. Overall patency of stent were 100, 85.7, 80%. There’s no statistical difference between three groups (p = 0.05). No major complication occurred, but perihepatic hematoma was occurred 22 days after LDLT in one patient of TH group, which was managed by percutaneous catheter drainage (PCD). Mild splenic infarction (less
Abstract No. 713

Cost analysis of using tunneled cuffed vs noncuffed peripherally inserted central catheters (PICC)
R. Ahuja1, J. Springer1, M. Callaghan1, B. Kilcoyne1, P. Brady1, B. Natarajan1, Albert Einstein Medical Center, Philadelphia, PA

Purpose: There is an increasing number of Tunneled PICC placements for IV access in patients who cannot receive regular PICC/Midlines per K-DOQI guidelines. We have been placing uncuffed PICCs that are tunneled into the internal jugular vein in lieu of a Tunneled PICC with a cuff. The purpose of this paper is to assess the cost effectiveness and efficacy of placing uncuffed PICC vs cuffed Tunneled PICC.

Materials: We reviewed our IR database for cases of Tunneled PICCs without cuff placed at our facility over an 8-year period. Tunneled PICC referral was automatic for patients with creatinine levels ≥ 3 mg/dL or post renal transplant regardless of creatinine level unless dialysis was not planned. All Tunneled PICC insertions, regardless of referral source, were identified and reviewed, and placements prompted by K-DOQI PICC contraindication were identified. Catheter types, cost of placement, replacement and removal as well as complications were ascertained.

Results: The total number of tunneled PICCs at our facility in the last 8 years was 1494, out of which a total of 172 were placed in the past year. Tunneled PICC removal as well as complications were ascertained.

Abstract No. 714

Single stick method for central venous port safety and efficacy
B. Fox1, J. Salsamendi2, P. Mohan2; 1Jackson Memorial Hospital, Miami, FL; 2University of Miami Miller School of Medicine, Miami, FL

Purpose: The aim of this study is to assess the safety and efficacy of the single incision technique for the placement of central venous port.

Materials: From a single institution, 113 consecutive patients who underwent central venous port (CVP) placement from 2011-17 using single incision technique were included in the study. These patients were compared with 113 consecutive patients who had CVP insertion by conventional technique. Data was obtained from the electronic medical records and PACS. In single incision technique, the creation of the pocket for the chest port is done first. From this subcutaneous pocket, a curved micro puncture needle is tunneled towards the internal jugular vein (IJV) under ultrasound guidance and the vein is punctured. After a series of exchanges, a 0.035" wire is advanced into the IVC, over which a vascular sheath is introduced into the SVC. The port catheter is then advanced through the vascular sheath into the right atrium, which will then be connected to the chest port. Independent sample t-test was used for analysis.

Results: 113 patients (46M, 67F) with average age of 53.8 years (SD 11.3) underwent CVP placement via the single incision technique. The mean procedure time was 35.9 minutes (SD 19.2). There were 3 minor complications according to SIR criteria. One patient had a small catheter fragment and another had a micro wire tip retained in the soft tissues. Third patient had port infection 44 days after insertion, which was removed. 113 patients (97M, 74F), average age of 51.8 years (SD 13.2), underwent CVP placement via the conventional method. The mean procedure time was 44.6 minutes, (SD 22.2). There were two minor complications, one patient had port infection 29 days after insertion, which was removed and another developed IJV thrombus. The mean procedure time was significantly shorter for single stick technique (p<0.01, mean time difference 8.7min, 95%CI: 3.3-14.2).

Conclusions: The single incision technique is a safe and efficient method for insertion of CVP. The shorter procedure duration noted in this study for single incision method is likely due to more experienced operators performing this technique.
placement method (P-CVS) and the coaxial central venous stent placement method (C-CVS) in patients who need concurrent central venous catheterization.

**Materials:** Central venous stent (CVS) placement for central venous obstruction resulting from malignant compression or catheter related stenosis was performed in 72 consecutive patients who were identified retrospectively over a 5-year period. Of patients, 38 (53%) underwent the P-CVS; 25 (35%) underwent the C-CVS; 9 (13%) underwent CVS deployment alone. The P-CVS is a method that the central venous catheter (CVC) is located between the CVS and the vessel wall, and the C-CVS is a method that the CVC is located in the lumen of the CVS. End points were CVS patency as determined by clinical symptoms or computed tomography (CT) and CVC function, which was determined by clinical performance.

**Results:** All procedures were technically successful. There was no difference between the P-CVS group and the C-CVS group in in-stent stenosis (P=.3). In-stent stenosis rates were 38% (9 of 24 patients) and 22% (4 of 18 patients) in P-CVS and C-CVS group, respectively. During the follow-up period, catheter malfunction was not reported in both groups. Two patients who included in the P-CVS group received catheter removal due to clinical need without complication.

**Conclusions:** The P-CVS does not compromise the stent patency or catheter function when compared to the previously performed the C-CVS. The P-CVS can be an alternative and simpler method for the patients who need concurrent central venous stent and central venous catheter placement.

---

**Abstract No. 716**

**Percutaneous microthrombectomy as an effective symptomatic treatment for uncomplicated superficial venous thrombophlebitis**

D. Kim\(^1\), C. Bolus\(^1\), S. Iqbal\(^1\), C. Molgaard\(^1\), H. Ahari\(^1\), S. Flocke\(^1\), B. Davison\(^1\); \(^1\)Lahey Hospital and Clinics, Burlington, MA

**Purpose:** Percutaneous needle puncture and thrombus evacuation has been described classically as an adjunct measure to prevent post-sclerotherapy skin hyperpigmentation and was also anecdotally described as a measure of symptomatic relief from venous wall distention by the clot. We questioned the efficacy of this minimally invasive technique in a patient with uncomplicated focal superficial venous thrombosis (SVT).

**Materials:** Ninety-eight consecutive patients (mean age, 48) with focal leg pain and fullness with documented venous insufficiency by Doppler ultrasound presented to an outpatient vein clinic between February 2006 and November 2011 were reviewed. Among these, 48 patients did not have a prior history of venous disease or treatment while 50 patients had recent venous interventions including sclerotherapy of saphenous tributaries (45) or endovenous laser therapy (5). Thirty-three patients (33.7%) were found to have SVT, while 4 patients had alternative diagnoses: soft tissue mass (3) and focal soft tissue infection (1). In the remainder, no clear diagnosis was established.

**Results:** Among 33 patients with SVT, twelve without prior vein treatment had focally dilated varicosities containing thrombus. Seven had SVT extending into a great saphenous vein, but at least 10 cm distal to saphenofemoral junction. Three had isolated single-segmental tributary SVT and two had multi-focal involvement within tributaries. Remaining 21 patients were found to have focal, less than 3 cm, tributary SVT without varicosities. One patient (3.1%) was placed on systemic low molecular weight heparin due to ascending extension of great saphenous SVT with no further improvement of pain. Thirty-one out of remaining 32 patients who underwent the needle/catheter microthrombectomy yielding immediate symptomatic relief (96.9%) after draining 0.2 to 4 ml of crankcase oil appearing thick fluid. 3 (9.4%) had recurrent pain and 17 (53.1%) complained of persistent focal hardness albeit less pain. No post-procedural complication was observed.

**Conclusions:** Percutaneous needle microthrombectomy is an effective symptomatic treatment in uncomplicated SVT, which can be performed and repeated in an outpatient setting without significant risks.
A.Fattah, Yasser 122, 125
Aaltonen, Eric 39, 40, 142, 603, 1068
Abad-Santos, Matthew 15
Abdelaziz, Ayman 122*, 124, 125*, 369
Abdelmaksoud, Mohamed H.K. 122*, 124, 125*, 369*, 509, 601
AbdelRazek, Mohammed A. 30, 88, 122, 124*, 125, 330, 369*, 509, 601
Abdelsalam, Mohamed 242*
Abdollahian, Davood 141
Abou-Zamzam, Ahmed 151
Abou-Chokh, Nadine 3, 81*, 86, 89, 268, 541, 546, 548, 549, 550
Abraham, Katherine 527
Abramowitz, Steven 352
Abruzzo, Todd 527
Abt, Peter 557
Abuelsalheen, Osama M. 122, 125
Addicott, Benjamin 146, 624
Agarwal, Deepak 337
Agarwal, Nitin 983
Ahari, Heideh 716
Ahmed, Noor 995
Ahmed, Altan 543, 556
Ahmed, Farres 631*, 986
Ahmed, Muneeb 609, 622
Ahmed, Osman 158, 380, 454
Ahn, Sun-Ho 199, 294, 298, 380, 456, 467, 570, 593, 594, 646, 647, 666, 707, 1012, 1058, 1085
Ahmadi, J. 691
Ahmad, Noor 995
Ahmed, Aftab 543, 556
Ahmed, Farres 631*, 986
Ahmed, Muneeb 609, 622
Ahmed, Osman 158, 380, 454
Ahn, Sun-Ho 199, 294, 298, 380, 456, 467, 570, 593, 594, 646, 647, 666, 707, 1012, 1058, 1085
Ahrar, Judy 691
Ahrar, Kamran 46, 51, 93, 149, 168, 180, 185, 225, 242, 245, 307, 316, 342, 374, 397, 444, 473, 475, 485, 573, 577, 578, 579, 580, 608, 705, 1027
Ahuja, Rakhi 641*, 713*
Akhtar, Naheed 263, 695
Akiwande, Olugbogbe 36, 104, 247, 283, 299, 324, 363, 397, 461, 480, 568, 585, 588, 617, 640, 647
Akman, Andrew 1073
Akpolat, Yusuf 28
Al Asadi, Ali 3, 81, 86, 89, 268, 541, 546, 548, 549, 550*
Al Khalifah, Abdullah 108*, 695, 710*

Note on Abstracts Order

Please note that the following abstracts are out of order due to scheduling changes: Nos. 254, 277, 362, 380, 388, 387, and 432.

*Indicates that the author is the presenter.

A-Hakim, Ramsey 156, 224*, 352, 384, 385, 406, 418, 662, 666, 673, 973, 987, 1081
A-Moaqel, Mohamad 165, 646, 648
A-Lo, William 94, 700
A-Badawi, Hassan 100, 220, 371, 406*, 452, 599
A-And, Arthur 416
A-Bin, Matthias 34
A-Elbright, Rhonda 59
A-Alexander, Erica 270*, 467, 1085
A-lexopoulos, Sophie 34
A-Alhrabi, Abdulaziz 646*, 648
A-Alhazzani, Abdulmajed 248
A-Ali, Doaa 583
A-Ali, Nada 291
A-Alicea, Christine 143
A-Alhathib, Sueybi 433
A-Allan, Emma G 381
A-Allegrecci, Andrew 615
A-Allen, David 658
A-Almehme, Ammar 238, 239, 583
A-Almeter, James 27
A-Alonzo, Marc 436
A-Alreichai, Bassam 165
A-Alt, Ali 412
A-Ashhehri, Shaker 248*, 399
A-Altaf, Sohaib 681*
A-Altmann, Ashley 147*
A-Alvarado, Cesar 543
A-Alvi, Abdulrahman 646
A-Amalou, Amel 219
A-Amalou, Hayet 213*, 219*
A-Ameer, Guillermo 317
A-Am, Ayush 184*, 253, 305, 306*, 670*
A-Amin, Sabina 21, 149, 304, 423, 424, 426, 469, 709
A-Amouyal, Gregory 189
A-An, Julie 85, 540
A-An, Xiao 355, 377
A-Anand, Dhanya 307*
A-Anastos, Harry 212, 336
A-Anders, Robert 105
A-Anderson, Michael 216
A-Ando, Tomohiro 425
A-Andreoli, Jessica 1080
A-Andrews, James 310, 361, 366, 524
A-Anelli, Vincenzo 251
A-Angela, Hirbe 256
A-Angle, J. Fritz 58, 207, 208, 387, 486, 657
A-Annamalai, Ganesan 367, 386*, 444
A-Ansari, Shahnawaz 502
A-Antokowiak, Mark 267*
A-Anton, Kevin 199*
A-Aoun, Heba 46, 334*, 498
A-Apisamthanarax, Smith 41
A-Apreedy, Ramana 999
A-Aquino, Jeneth 150
A-Aquisto, Thomas 436
Aragona, Emily 630
Araki, Yuta 694
Aramplukan, Joseph 230
Arellano, Ronald 126, 175, 398
Arendt, Victoria 355*, 357, 638
Arepally, Aravind 104, 105, 131, 133
Aria, David 594
Amdt, Stephen 33, 35, 181*, 274* 488*, 504*, 1042
Arnold, Ryan 656
Aryafar, Hamed 60, 284
Aryan, Lavanya 27
Ashton, Daniel 115
Asrani, Sumeet 70
Assael, Dylan 633
Asvadi, Nazanin 398*
Athreya, Sriharsha 1069
Augenstein, Vedra 578
Averkiou, Michalakis 218
Avignon, Gregoire 644
Awai, Kazuo 482
Azene, Ezana 14, 31, 39, 91, 154, 204, 213, 364, 385, 393, 440, 516, 522, 564, 581, 713, 1031, 1045, 1058
Azour, Lea 97

Baba, Yasutaka 482*
Babin, Ivan 664*
Back, Susan 1059
Bader, Mohammad 658
Bae, Suk Hyun 138*
Bagla, Sandeep 201, 206*, 210*, 490*
Baheti, Arvin 241
Bai, Harrison 973
Baijai, Sanjay Saran 337
Bail, Harrison 973
Bakal, Curtis 75, 76, 143, 222, 300, 381, 407, 436, 569, 572, 599, 668, 705, 1012, 1067, 1069
Baker, Jennifer 34
Bakhutashvili, Ivane 319, 652
Bakshi, Darshan 217
Baleari, Arun 362
Bale, Reto 215
Ball, David 70, 91, 139, 195, 199, 211, 273, 456, 511, 564, 567, 671, 1004, 1043, 1052
Ballah, Deddeh 302*
Banovac, Filip 34, 150
Bansal, Asshank 414
Bant, Raj 27, 174, 521
Baral, Sunil 420
Baran, Timothy 200
Barazani, Sharon 352
Barbon, Dennis 460*
Baron, Anael 147
Baron, Christopher 150
Barreira, Christian 196
Barton, Robert 1077
Bashir, Omar 165
Bassaco, Beatriz 216
Bataoul, Ali 20
Baum, Richard 20, 67, 71, 149, 308, 310, 370, 405, 458, 468, 474, 479, 554, 583, 588, 591, 607
Baumhauer, Annette 379
Bautista, Jerimie 395*
Baxter, Aaron 503
Beall, Douglas 592*, 1057
Beardsley, Adam 481*, 523*
Beasley, Robert 150*, 230, 307, 357, 387, 399, 410, 411, 413, 415, 442, 443, 674, 995
Beck, Avi 26, 55, 79, 198, 210, 218, 237, 243, 275, 373, 426, 449, 483, 500, 573, 692, 713
Beecroft, J. Robert 367
Bermingham, Christopher 626
Bermudez, Jacob 614
Berrier, Helen 490
Bertino, Frederic 119*
Bertoni, Herman 385, 409
Beschio, David 245, 246
Bessissow, Ali 1053
Betancourt, Hector 1067
Betz, Joshua 106
Bevis, Nicholas 545
Beyer, Lukas 688
Bezold, Samuel 534
Bhagat, Nikhil 12, 31, 99, 153, 157, 208, 311, 383, 456, 663, 667
Bhagavatula, Sharath 214*
Bhanot, Shelly 698*
Bharadwaj, Aditiya 438
Bhatia, Shivank 4, 5, 7*, 9, 10, 135, 209, 280, 422, 426, 510, 630, 985
Bhattcharji, Priya 97
Bhattacharya, Kieran 387
Bhatti, Zagon 183, 698
Bhujade, Harish 177
Biederman, Derek 243, 515, 520, 537*, 538*, 1040
Bigot, Alexandre 314
Biko, David 487
Bilbey, Nicolas 241
Bimrey, Alan 581, 633*
Bishay, Vivian 52, 101, 121, 129, 130, 176, 222, 243, 244, 266, 326, 411, 515, 520, 581, 619, 633, 650, 697, 984
Bishop, Cailyn 651
Bista, Biraj 1022
Biswas, Pradipra 211
Bittman, Ross 160
Bjarnason, Haraldur 366, 389
Boas, Franz 94, 117, 258, 264, 322, 325, 328*, 340, 1035
Bodina, Teodora 400, 611
Bodoky, Gyorgy 379
Bohorquez, Humberto 33, 35, 274
Bold, Michael 421
Bolger Theut, Stephanie 708
Bolstrem, Shenita 490
Bolus, Christopher 716
Bondarev, Sergey 634*
Bones, Brian 14*, 21, 418
Bonne, Lawrence 686, 690
Boodram, Sandra 143
Borgmann, Tony 34, 150
Borja-Cacho, Daniel 534
Borys, Nicholas 178
Bosch Melguizo, Jordi 169
Boucher, Louis-Martin 1053
Boyd, Christina 410
Boyd, John 999
Bozorgchami, Hormozd 360, 441
Bozorgmehri, Shahab 543
Brace, Christopher 48
Brady, Paul 641, 713
Brandis, Aaron 155, 457
Brannan, Joseph 347
Brar, Anantnoor 1077
Braun, Ryan 603
Bravo, Eduardo 327, 518
Bravo, Juan Carlos 327, 518
Bream, Peter 150
Breder, Valeriy 379
Brejt, Sidney 73, 120, 582, 653
Brelje, Tim 490
Bricco, Diane 71
Brock, Malcolm 591
Bromberg, Jacqueline 264
Bronowicki, Jean-Pierre 379
Brook, Olga 26, 68, 77, 80, 147, 185, 222, 499, 554, 666, 681, 683, 1028
Bromberg, Jacqueline 264
Brower, Jayson 263
Brown, Daniel 34, 150
Brown, James 98
Brown, Karen 94, 322, 328
Brown, Matthew 555
Brown, Ronnie 318
Brown, Travis 708
Browne, William 644
Bruix, Jordi 379
Bruns-Augello, Geraldine 97
Bryce, Yolanda 94, 254, 264
Buck, David 20
Buckley, Donna 85, 134, 273, 278, 540, 564, 1013
Buether, Ji 276, 343, 344, 400, 591
Bui, Kevin 43, 49, 53
Bukata, Susan 388
Bullen, Jennifer 294, 477
Bundy, Jacob 168, 589
Burner, Scott 14, 418
Burns, Kevin 607
Burnows, Patricia 5, 15, 110, 111, 190, 210, 419, 485, 552, 597, 643, 986, 987
Burshtein, Mark 277
Burt, Jeremy 211
Bustreo, Sara 396
Butani, Devang 362, 558
Cabrera, Tatiana 1053
Cahalane, Alexis 235, 551
Cahill, Anne Marie 196, 1059
Cain, Charles 394
Calabrese, Lawrence 25, 131, 133, 135, 181, 189, 244, 256, 257, 271, 272, 274, 278, 332, 343, 477, 481, 486, 487, 512, 555, 683, 1032
Calandri, Marco 396
Call-Pont, Marcella 661
Callhouen, Sean 410
Callaghan, Matt 713
Calvo, Aitana 375
Camacho, Juan 43, 168, 187, 216, 249, 251, 303, 312, 319, 338, 339, 397, 449, 520, 526, 701
Cameron, Andrew 276
Campion, Andrew 110
Campos, Leonardo 624
Cannata, Jon 339, 392
Cantos, Andrew 113, 200
Cantwell, Colin 49, 64, 120, 138, 179, 248, 314, 398, 420, 489, 495, 691, 702, 1053
Cao, Guohong 135
Capel, Jeroen 70
Cappelli, Federico 251
Cappello, Joseph 407
Cardella, John 85, 134, 273, 278, 430, 540, 564, 1013
Cardenas, Nicolas 183
Caridi, Theresa 85, 134, 273, 278, 311, 430, 540, 564, 1013
Carlin, Sean 32, 528
Carrelli, Paolo 427
Carrick, Michael 212, 336
Carrier, Amber 21
Carroll, Jason 29
Castro, Meryll 178
Caton, Michael 332, 335
Caviedes, Gabriel 1053
Celik, Haydar 178, 219
Cellini, Michael 669
Cengel, Keith 265
Ceremenati, Tomas 327, 518
Cerna, Marie 384, 443
Cernik, David 443
Cha, Victoria 438
Chakaramakkil, Mathew Jose 381
Chan, Emily 375
Chan, Gabriel 179
Chan, HingKiu 207, 208, 387
Chan, Lauren 5, 18, 137, 162, 181, 208, 321, 354, 377, 423, 624, 649, 712, 985, 1033
Chan, Shaun Xavier Ju Min 64
Chandrapatap, Sarat 264
Chandora, Kapil 54
Chandrarmohan, Sivanathan 64, 381
Chang, Cheng-Kuang 565
Chang, Hsiang-Chi 60
Chang, Hung 565
Chang, Jodie 324
Chang, Kai-Hsiang 272
Chang, Paul 147
Chang, Ping-Ying 378
Chang, Randy 491
Chang, Seon Hee 446
Chang, Steven 661
Chang, Wei-Chou 272, 378
Chang, Young 113, 200
Chao, Chener 35, 94, 99, 246, 263, 264, 284, 347, 434, 493, 494, 496, 503, 518, 529, 549, 688, 1044
Chapiro, Julius 331, 517
Chapman, Michael 458
Chappell, Matthew 570, 572
Charalel, Resmi 283, 324, 588
Chastain, Katherine 708
Chau, Alex 111, 115
Chauhan, Nirav 1010
Chawla, Yogesh 177
Chedrawy, Christelle 223, 225, 353
<table>
<thead>
<tr>
<th>Name</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chen, Allen</td>
<td>436*</td>
</tr>
<tr>
<td>Chen, Angela</td>
<td>38, 46, 175, 187, 259, 325, 338, 344, 350, 374, 446, 448, 452, 1002, 1031</td>
</tr>
<tr>
<td>Chen, Bertha</td>
<td>1064</td>
</tr>
<tr>
<td>Chen, Evan</td>
<td>51</td>
</tr>
<tr>
<td>Chen, Huan-qiu</td>
<td>526</td>
</tr>
<tr>
<td>Chen, James</td>
<td>149, 1000</td>
</tr>
<tr>
<td>Chen, Jesse</td>
<td>995</td>
</tr>
<tr>
<td>Chen, Jun</td>
<td>526</td>
</tr>
<tr>
<td>Chen, Kan</td>
<td>484*</td>
</tr>
<tr>
<td>Chen, Li</td>
<td>170</td>
</tr>
<tr>
<td>Chen, Shi-Xi</td>
<td>38</td>
</tr>
<tr>
<td>Chen, Yi-Fan</td>
<td>376, 391</td>
</tr>
<tr>
<td>Cheng, Wayne</td>
<td>148*</td>
</tr>
<tr>
<td>Chengazi, Harris</td>
<td>362*</td>
</tr>
<tr>
<td>Chervoni-Knapp</td>
<td>416</td>
</tr>
<tr>
<td>Chervonski, Michael</td>
<td>539, 696</td>
</tr>
<tr>
<td>Cheskin, Lawrence</td>
<td>104</td>
</tr>
<tr>
<td>Chesney, Jason</td>
<td>375</td>
</tr>
<tr>
<td>Chhabra, Avneesh</td>
<td>580</td>
</tr>
<tr>
<td>Chheang, Sophie</td>
<td>73</td>
</tr>
<tr>
<td>Chiarello, Matthew</td>
<td>39*, 40*</td>
</tr>
<tr>
<td>Chintalapani, Gouthami</td>
<td>182, 259, 512</td>
</tr>
<tr>
<td>Chittams, Jesse</td>
<td>26</td>
</tr>
<tr>
<td>Chiu, Sherwin</td>
<td>290*</td>
</tr>
<tr>
<td>Chivate, Rahul</td>
<td>257</td>
</tr>
<tr>
<td>Cho, Alex</td>
<td>987</td>
</tr>
<tr>
<td>Cho, Clifford</td>
<td>339</td>
</tr>
<tr>
<td>Cho, Soojeong</td>
<td>313, 350, 1032, 1052</td>
</tr>
<tr>
<td>Cho, Sung Burn</td>
<td>699</td>
</tr>
<tr>
<td>Cho, Sung Ki</td>
<td>138, 645</td>
</tr>
<tr>
<td>Choi, Byung Gil</td>
<td>715</td>
</tr>
<tr>
<td>Choi, Dong Wook</td>
<td>645</td>
</tr>
<tr>
<td>Choi, Jae Woong</td>
<td>689*</td>
</tr>
<tr>
<td>Choi, Junsung</td>
<td>402</td>
</tr>
<tr>
<td>Choi, Sun Young</td>
<td>692*</td>
</tr>
<tr>
<td>Choi, Won Kyu</td>
<td>106, 469*</td>
</tr>
<tr>
<td>Choi, Woosun</td>
<td>102, 671, 989</td>
</tr>
<tr>
<td>Choi, Young Ho</td>
<td>482</td>
</tr>
<tr>
<td>Chosa, Keigo</td>
<td>482</td>
</tr>
<tr>
<td>Chou, Frank</td>
<td>37</td>
</tr>
<tr>
<td>Chou, Frank</td>
<td>82, 84</td>
</tr>
<tr>
<td>Chou, Yu-Ching</td>
<td>272, 378</td>
</tr>
<tr>
<td>Chowdhury, Sabeeca</td>
<td>85*, 540, 564</td>
</tr>
<tr>
<td>Choy, Edwin</td>
<td>45</td>
</tr>
<tr>
<td>Chrisman, Howard</td>
<td>73, 78, 80, 222, 292, 472, 473, 630, 680, 1012</td>
</tr>
<tr>
<td>Christensen, Diana</td>
<td>1030</td>
</tr>
<tr>
<td>Christie, Alexander</td>
<td>96</td>
</tr>
<tr>
<td>Chu, Ferdinand</td>
<td>628</td>
</tr>
<tr>
<td>Chu, Hee Ho</td>
<td>636, 637</td>
</tr>
<tr>
<td>Chu, Katrina</td>
<td>126*</td>
</tr>
<tr>
<td>Chun, Albert</td>
<td>682, 1073</td>
</tr>
<tr>
<td>Chun, Albert</td>
<td>442</td>
</tr>
<tr>
<td>Chun, Ho Jong</td>
<td>715</td>
</tr>
<tr>
<td>Chung, Eun Chul</td>
<td>685*, 701*</td>
</tr>
<tr>
<td>Chung, Hwan Hoon</td>
<td>683</td>
</tr>
<tr>
<td>Chung, Jin Wook</td>
<td>535, 536, 1032, 1033</td>
</tr>
<tr>
<td>Chung, John</td>
<td>37, 82, 84, 159</td>
</tr>
<tr>
<td>Chung, Raymond</td>
<td>615</td>
</tr>
<tr>
<td>Cihlar, Filip</td>
<td>443</td>
</tr>
<tr>
<td>Citron, Steven</td>
<td>131</td>
</tr>
<tr>
<td>Cizman, Ziga</td>
<td>95, 656</td>
</tr>
<tr>
<td>Clark, Timothy</td>
<td>62, 155, 288</td>
</tr>
<tr>
<td>Clausen, Lisa</td>
<td>423</td>
</tr>
<tr>
<td>Clayton, Bishir</td>
<td>454</td>
</tr>
<tr>
<td>Cleveland, Heather</td>
<td>111, 115*</td>
</tr>
<tr>
<td>Cline, Brendan</td>
<td>233*</td>
</tr>
<tr>
<td>Cobb, Ryan</td>
<td>277</td>
</tr>
<tr>
<td>Cochran, Rory</td>
<td>302, 439*</td>
</tr>
<tr>
<td>Cohen, Ari</td>
<td>33, 35, 274</td>
</tr>
<tr>
<td>Cohen, Emil</td>
<td>85, 134, 273, 278, 540, 564, 1013</td>
</tr>
<tr>
<td>Cohen, Gary</td>
<td>277</td>
</tr>
<tr>
<td>Cohn, David</td>
<td>355, 357*, 638</td>
</tr>
<tr>
<td>Colavita, Paul</td>
<td>578</td>
</tr>
<tr>
<td>Coldwell, Douglas</td>
<td>13, 90, 642</td>
</tr>
<tr>
<td>Coleman, Jonathan</td>
<td>321, 450</td>
</tr>
<tr>
<td>Collaco, Joseph</td>
<td>75</td>
</tr>
<tr>
<td>Collard, Michael</td>
<td>580*</td>
</tr>
<tr>
<td>Collares, Felipe</td>
<td>609</td>
</tr>
<tr>
<td>Collins, Daniel</td>
<td>427</td>
</tr>
<tr>
<td>Collins, Jeremy</td>
<td>630</td>
</tr>
<tr>
<td>Comerota, Anthony</td>
<td>351, 354</td>
</tr>
<tr>
<td>Commander, Clayton</td>
<td>18, 22</td>
</tr>
<tr>
<td>Connolly, Michael</td>
<td>180*</td>
</tr>
<tr>
<td>Connolly, Sarah</td>
<td>461</td>
</tr>
<tr>
<td>Connors, Thomas</td>
<td>93*, 608*</td>
</tr>
<tr>
<td>Conrad, Miles</td>
<td>107*, 293</td>
</tr>
<tr>
<td>Contrela, Benjamin</td>
<td>208*</td>
</tr>
<tr>
<td>Contreras, Francis</td>
<td>133, 228*</td>
</tr>
<tr>
<td>Cook, Tessa</td>
<td>149</td>
</tr>
<tr>
<td>Cool, Dekalb</td>
<td>187*, 248</td>
</tr>
<tr>
<td>Cooper, Cathleen</td>
<td>29, 539</td>
</tr>
<tr>
<td>Cooper, Kyle</td>
<td>28, 148, 207, 228, 360, 368, 404, 438, 443, 457, 567, 653, 661, 677, 989, 1022</td>
</tr>
<tr>
<td>Cooper, Randy</td>
<td>231</td>
</tr>
<tr>
<td>Corbin, Ian</td>
<td>318</td>
</tr>
<tr>
<td>Core, Jacob</td>
<td>556*</td>
</tr>
<tr>
<td>Corn, David</td>
<td>577, 579</td>
</tr>
<tr>
<td>Cornish, Nathan</td>
<td>687*</td>
</tr>
<tr>
<td>Coronado-Homonoff</td>
<td>148, 203*, 417</td>
</tr>
<tr>
<td>Correa, Marcelo</td>
<td>407</td>
</tr>
<tr>
<td>Correa, Zelia</td>
<td>527</td>
</tr>
<tr>
<td>Cortes, Andrea</td>
<td>338, 446*, 449*</td>
</tr>
<tr>
<td>Cortes, Andrew</td>
<td>18*, 22*</td>
</tr>
<tr>
<td>Covey, Anne</td>
<td>94, 322</td>
</tr>
<tr>
<td>Cox, Moungnyan</td>
<td>983</td>
</tr>
<tr>
<td>Crago, Aimée</td>
<td>258</td>
</tr>
<tr>
<td>Cressman, Erik</td>
<td>338, 374, 447, 1031</td>
</tr>
<tr>
<td>Criado Paredes, Eva</td>
<td>169</td>
</tr>
<tr>
<td>Cristescu, Mircea</td>
<td>101, 392, 619</td>
</tr>
<tr>
<td>Critchfield, Jeffrey</td>
<td>11, 15, 98, 159, 190, 227, 307, 403, 408, 441, 487, 498, 542, 662, 664, 681, 682, 683, 989, 1004, 1027, 1041</td>
</tr>
<tr>
<td>Crosier, M'Liss</td>
<td>98</td>
</tr>
<tr>
<td>Cruz, Jeffrey</td>
<td>34</td>
</tr>
<tr>
<td>Cubillo, Antonio</td>
<td>375</td>
</tr>
<tr>
<td>Cui, Jie</td>
<td>235, 455</td>
</tr>
<tr>
<td>Cully, Brent</td>
<td>708</td>
</tr>
<tr>
<td>Culp, William</td>
<td>71</td>
</tr>
<tr>
<td>Cummings, Dennis</td>
<td>396*</td>
</tr>
<tr>
<td>Cura, Marco</td>
<td>21, 34, 41, 82, 86, 109, 128, 136*, 164, 172, 178, 261, 278, 324, 326, 336, 424, 428, 556, 562</td>
</tr>
<tr>
<td>Curnes, Nicole</td>
<td>26*</td>
</tr>
<tr>
<td>Cusumano, Lucas</td>
<td>109*</td>
</tr>
<tr>
<td>Cynamon, Jacob</td>
<td>370, 473, 499, 547, 623</td>
</tr>
</tbody>
</table>

**-D-**

D’Archambeau, Olivier 202*
D’Souza, Julia 32*, 467*, 528*, 1085
Dabrowiecki, Alexander 19*, 54, 55
Dagli, Manoel 41, 265, 288, 341
Dailela, Taylor 51, 91, 282, 501, 625, 1028
Dalag, Leonard 436
Damjanov, Nevena 265
Damodharan, Karthikeyan 64, 381
Darcy, Michael 283, 299, 324, 617
Darge, Kasse 487, 1059
Darshani, Sean 19
Darwish, Ahmed Gamal Eldin 122, 125
Das, Dola 573, 451
Dasika, Narasimham 621
Dargie, Kasse 487, 1059
Dariushnia, Sean 19
Darwish, Ahmed Gamal Eldin 122, 125
Das, Dola 373, 451
Dasika, Narasimham 621
Davidson, Jon 18, 33, 85, 201, 209, 292, 318, 401, 451, 459, 474, 517, 539, 611, 633, 984, 986, 1033, 1046, 1073
Davies, Erik 204
Davies, Gareth 626
Davison, Brian 716
Dawson, Monique 141
Daye, Dania 332, 335
De Gracia, Jose 327, 358
De Gregorio, Miguel 54, 56, 62, 169, 228, 229, 361, 387, 556, 560, 565, 999, 1080
De Paepe, Katja 686, 690
Dean, Carole 189
DeColli, Danielle 199
Degerstedt, Spencer 146
Degeyer, Kyle 427
Dehghani, Hossein 211
Deipolyi, Amy 94, 254, 264
Deitrick, Ginna 265
Del Giudicce, Costantino 189
DeLorenzo, Matthew 76
DeMeritt, John 416
Demmert, Andrew 141, 651
Denker, Susie 141
DePietro, Allegra 126
DePopas, Eric 555
Der, Dennis 395
DeRubertis, Brian 25
Desai, Khanant 575
Desai, Shamit 308
Desai, Sudhen 111
Desjardins, Benoit 26
Devicic, Zlatko 30
Devulapalli, Kavi 18, 22, 632
DeVun, Daniel 33, 35, 274, 488, 504, 1042
Dewhirst, Mark 178
Di Capua, John 515
Diaz, Alex 459
Dickey, Kevin 14, 418
Dickey, Melissa 107
Dillavou, Ellen 233
Ding, Wei 493
Dinglasan, LuAnne 16, 642
Dinicola, Jenifer 141
Dixon, Katherine 1031
Dixon, Robert 307
Do, John 296
Doddakashi, Satish 641
Dodge, Cristina 481
Dodge, Jennifer 525
Dokus, M. Katherine 362
Dolan, Ryan 579
Donaldson, James 595
Donaldson, Jeffrey 472
Donelson, Randy 372, 377
Dong, Paul 302, 439, 440
Dovovan, Kevin 988
Dorman, Christopher 209
Dortche, Kristina 155
Doshteh, Shohreh 64, 381
Drabkin, Michael 472
Drescher, Peter 158, 227, 369, 381, 388, 438, 441, 453, 656, 661, 662, 672, 973, 1002
Dria, Stephen 59
Druta, Michael 693
Du Pisanie, Johannes 988
Dubel, Gregory 456, 707
Dubin, Brian 172
Duckwiler, Gary 109
Durexer, Christoph 1014
Dublaigan, Essam 646
Duncan, James 613
Dunlap, Robert 304, 437, 651
Dunlay, Michael 519
Dunn, Aaron 97, 143, 163, 186, 240, 439, 442, 482, 483, 495, 514, 520, 542, 585, 590, 614, 659, 686, 1030
Dupuy, Damian 2, 489
Durack, Jeremy 94
Durand, Rachelle 1059
Durningau, Renuka 1027
Dunne, Raja 5, 28, 96, 106, 204, 220, 235, 422, 430, 454, 455, 482, 484, 677
Durwas, Kanak 572
Duryea, Alex 339
Duvvuri, Madhavi 106
D’Angelo, Sandra 258
Echenique, Ana 249
Edwards, Janetta 294
Eggers, Mitchell 59
Eifler, Aaron 638
Einstein, Andrew 29
Eisenmenger, Laura 407
Elizra, Raja 5, 28, 96, 106, 204, 220, 235, 422, 430, 454, 455, 482, 484, 677
Engstrom, Bjorn 198
Ensor, Joe 182
Epelboym, Van 575
Erisen, Joseph 2, 94, 117, 258, 325, 328, 1035
Ermantrou, Robert 533
Ertel, Nathan 137, 238, 239, 285, 290, 583, 612
Ertreo, Marco 85, 540
Eschelman, David 51, 75, 181, 279, 311, 362, 444, 445, 473, 504, 527, 552, 553, 639, 678
Escobar, Fernando 196
Esparza-Trujillo, Juan 319, 652
Etezadi, Vahid 108, 710
Evangelista, Michelle 143
Evans, Christopher 684
Eynar, Agata 315
Fabrizio, Raymond 433, 457
Fagbongbe, Eniola 451
Faintuch, Salomao 323, 350, 423, 513, 528, 566, 587, 589, 650, 702, 706, 1032, 1035, 1036
Fan, Chieh-Min 69
Fan, Hsiu-Lung 272, 378
Fan, Wenzhe 279*
Fanelli, Fabrizio 13, 157, 169, 284, 302, 360, 461, 559, 618, 1085
Fang, Adam 6, 27, 28, 84, 174, 265, 313, 361, 363, 403, 520, 521, 541, 617, 621, 635, 640, 694, 696, 1079
Faridnia, Masoud 191, 193
Farrell, Mary Beth 77
Farrell, Tony 154, 196, 239, 299, 337, 436, 471, 499, 564, 586, 686, 706, 1010, 1069, 1070
Farsad, Khashayar 262, 287, 312*, 358, 360, 624, 626*, 1077
Fassiotto, Magali 292, 470
Fayazzadeh, Ehsan 140, 185, 204, 267, 268*, 269, 275, 276, 309, 327, 334, 346, 374, 390, 397, 419, 432, 495, 497, 523, 526, 529, 532, 541*, 546, 548, 549, 550, 613, 619, 697
Feller, John 297, 471
Feng, Alex 364
Feng, Guo-dong 526
Feng, Jian-fang 526
Fenn, Aloke 382*
Fenster, Tamatha 417
Fermin, Esteban 143
Fernandes, Kevin 616
Fernandes, Nelson 72
Fernando, Dayantha 43, 49, 53
Fernando, Ruksan 1053
Ferraro, John 133
Field, David 85, 134, 273, 278, 540, 564, 1013
Field, David 85, 134, 273, 278, 540, 564, 1013
Figueroa Cacacho, Ana 229
Finkelstein, Mark 52, 222*, 697*
Finn, Aloke 382*
Finn, Paul 25, 1022
Fintelmann, Florian 45, 332, 335
Fiore, Courtney 69
Fischman, Aaron 11, 52, 101, 104, 121, 129, 130, 131, 133, 176, 222, 243, 244, 266, 325, 411, 420, 515, 520, 532, 537, 538, 581, 619, 633, 650, 697, 984, 1040
Fishbein, Gregory 388
Fishbein, Michael 388
Flacke, Sebastian 716
Flanagan, Siobhan 364*
Fleischer, Deborah 574
Fleming, Chad 310, 361, 524
Fleming, Jacob 34, 466
Fletcher, Savannah 534*
Fletcher, Will 516*
Florek, Rodney 98*
Flynn, Courtney 606*
Flynn, Patricia 1067
Foltz, Gretchen 299, 324, 461
Fonio, Paolo 396
Ford-Glanton, Sophia 6
Foss, Wylie 95*
Fratiadis, Nicholas 686, 690
Fox, Bradley 666*, 714*
Frank, Nicholas 655
Frantz, Shelby 263*
Frederick, R. 70
French, Travis 479
Frenk, Nathan 332, 335, 615*
Frenkel, Joseph 120*
Frey, Gregory 556
Frische, Micah 34
Frohbergh, Michael 592, 1057
Frois, Stella 154, 444, 610
Froud, Tatiana 494*, 1024
Fujimori, Masashi 349, 448
Fujii, Tomoyo 482
Fujimori, Masashi 321*, 450
Fujimoto, Scott 132
Funk, Brian 147
Funs, Daniel 36*
Gab, Ron 40, 226, 271, 284, 320, 321, 327, 348, 373, 376, 377, 391, 446, 448, 449, 500, 625
Gabel, Joshua 151
Gabriel, Courtney 265
Gade, Terence 32, 62, 270, 316, 320, 333, 342, 348, 496, 514, 528, 530, 1000
Gadodia, Gaurav 114*, 293*
Gage, Shawn 233
Gala, Kunal 257, 561
Galle, Peter 1014
Galliano, Gretchen 33
Gandhi, Rozil 561
Gandras, Eric 484
Ganguli, Suvarnai 2, 7, 76*, 126, 175, 176, 205, 214, 288, 304, 324, 352, 368, 525, 530, 543, 551, 615, 995, 1074, 1079, 1082
Gans, Daniel 58
Gans, Jared 473, 547*
Gao, Hong-Wei 565
Garca, Mark 351*, 353, 639
Garcia-Reyes, Kirema 1043
Gardner, Brian 387, 486
Gardner, Gregory 111
Gardner, Julie 523
Garwood, Michael 377
Garza-Berlanga, Andres 173
Gasparis, Antonios 415
Gaston, Charles 1045
Gaviera, Carlo 396
Gebe, Todd 27
Ge, Michael 332, 335
Gevarghese, Sunil 34
Gillard, Rondi 19
Geller, Brian 543
Geller, David 995
Gemmete, Joseph 168, 174, 200, 245, 246, 251, 352, 428, 490, 492, 584, 589, 598, 621, 628
Gendel, Vyacheslav 103
Georgiades, Christos 276, 343, 344, 513, 591
Gerhardson, Tyler 495
Gerolami, Rene 379
Green, Chelsey 392
Grenier, Nicolas 453
Greve, Joan 495
Gribbin, Christopher 103
Griffin, Andrew 233
Grilli, Christopher 223, 225, 353, 639
Grinshpoon, Alon 29
Gross, Jonathan 603
Groth, Dale 408, 423
Gruener, Jason 619
Grupp, Stephan A 196
Guan, Justin 519
Guidry, Russ 652
Guimarães, Marcelo 4, 7, 16, 72, 106, 141, 216, 305, 322, 332, 357, 366, 392, 429, 497, 506, 507, 601, 606, 984, 1067, 1068, 1076
Guirola Ortiz, Jose Andrés 169, 229
Gulati, Gurpreet 1
Gulaya, Karan 89
Gula, Paul 33, 35, 274, 504, 1042
Gunasekaran, Senthil 53
Gunn, Andrew 137, 285*, 309*, 612
Guo, Chunxiao 374*, 447, 1031
Guo, Jin-He 163, 1076
Guo, Xiaohua 401
Gupta, Pankaj 177
Gupta, Ramona 92, 93, 120, 175, 177, 233, 358, 359, 508, 573, 639, 640, 703, 1024, 1044, 1052
Gupta, Saurabh 337
Gupta, Suraj 308
Gupta, Vikash 674*, 695*
Gurajala, Ram Kishore 477
Gurakar, Ahmet 276
Gusman, Mariya 79
Gustin, Michael C. 374, 447
Guha, Narendra Babu 466
Guy, Gregory 463
Guyan, John 27, 174, 521
Guzman, Grace 376, 391
Gwon, Dong Il 636, 637

---

Habibollahi, Peiman 341*, 530
Haddad, Mustafa 310, 361*, 366*, 421*, 422*
Hadjiavassi, Anastasia 159
Hagi, Anthony 168, 352, 356, 419, 567, 589, 621
Haider, Steffen 539*, 696
Haimerl, Michael 688*
Hairston, John 3
Hairston, John 432
Hakim, Wasim 412
Halkier, Bradley 241
Hall, Andrew 6, 27*, 403
Hall, Melissa 627
Hall, Timothy 394, 495
Hamed, Basant 238, 239, 290, 583
Hamilton, Blake 246
Hamm, Charlie 517
Hammel, Benjamin 97, 143, 163, 186, 240, 433, 439, 442, 457, 482, 483, 495, 514, 520, 542, 585, 590, 614, 659, 686, 1030
Katrivesis, James 43, 49, 53
Katsanos, Konstantinos 236, 237
Katz, Danielle 88
Katz, Douglas 479
Katz, Michael 133
Katz, Barry 77
Kaufman, Claire 656
Kaufman, John 8, 207, 221, 262, 295, 355, 437, 460, 462, 467, 622, 624, 626, 670, 678, 1027
Kavalci, Pavan 234, 283, 553
Kawada, Hiroshi 425
Kawai, Nobuyuki 425
Kay, Dennis 33, 35, 274, 488, 504, 1042
Kaye, Elena 340
Kaye, Robin 594
Keating, Lawrence 427
Kee, Stephen 25, 110, 157, 224, 354, 355, 369, 410, 415, 616, 617, 619, 628, 636, 660, 1002, 1074
Keeffe, Nicole 153
Keller, Eric 301, 630
Kelley, Robin 271
Kelman, Julie 92
Kemeny, Nancy 340
Keohan, Mary 258
Kiefer, Ryan 32, 320, 528, 1000
Kies, Darren 533
Kies, Darren David 54, 55
Kilcoyne, Brittany 713
Kim, Alexander 278, 1013
Kim, Alexander 85, 133, 134, 218, 261, 263, 273, 314, 326, 328, 330, 418, 437, 447, 491, 493, 502, 531, 540, 545, 564, 626, 988
Kim, Chang Won 17, 413, 569, 667, 1047
Kim, Dae Hee 716
Kim, Danny 1068
Kim, David 640
Kim, Dennis 15
Kim, Dong-Hyun 313, 350, 1032, 1052
Kim, Edward 11, 52, 101, 121, 129, 130, 176, 222, 243, 244, 266, 262, 411, 420, 515, 520, 532, 537, 538, 581, 619, 633, 650, 697, 984, 1040
Kim, Eleanor 653
Kim, Eu Hyun 715
Kim, Gyoung Min 102, 671, 989
Kim, Haewon 535
Kim, Hongsik 45, 240, 261, 323, 345
Kim, Jeong Woo 689
Kim, Jeremy 18, 22
Kim, Jin Hyeok 704, 712
Kim, Jin Hyoung 636, 637
Kim, Jinoo 672, 676, 677
Kim, Jong Woo 636, 637
Kim, Ki Hyun 673
Kim, Kyeong Hwan 673
Kim, Kun Yung 685, 701
Kim, Kyung Il 402
Kim, Kyung Tae 102, 671
Kim, Yong Hwan 699
Kim, Yong Seek 989
Kim, Yu Kyung 1032
Kim, Yun Hwan 699
Kim, Yonjae 629, 712
Kim, You Kyung 102, 671
Kim, Youn 629, 711
Kim, Yonjae 629, 711
Kim, Yoon 1032
Kinsch, David 33, 35, 274
Kissane, Jennifer 192
Kitrou, Panagiotis 236, 237
Klebanoff, Christopher 264
Klimkowski, Sergio 309
Klobuka, Andrew 472
Knebel, Robert 684
Knight, Jacquelyn 577, 579
Knott, Emily 339
Knox, Joseph 554
Knuttinen, Martha 599
<table>
<thead>
<tr>
<th>Name</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lepkovic, Safet</td>
<td>11, 121, 532*</td>
</tr>
<tr>
<td>Lencioni, Riccardo</td>
<td>139*, 178, 249, 305, 306, 494, 654, 670, 1024</td>
</tr>
<tr>
<td>Leon, Boris</td>
<td>327, 518</td>
</tr>
<tr>
<td>Leon, Luis</td>
<td>415*</td>
</tr>
<tr>
<td>Leon Guerrero,</td>
<td>Christopher 442</td>
</tr>
<tr>
<td>Leonard, Shelby</td>
<td>178, 319</td>
</tr>
<tr>
<td>Leong, Sum</td>
<td>157, 381</td>
</tr>
<tr>
<td>Lerman, Sheldon</td>
<td>547</td>
</tr>
<tr>
<td>Leschak, Stephen</td>
<td>127</td>
</tr>
<tr>
<td>Lessne, Mark</td>
<td>24, 53, 148, 151, 191, 285, 301, 420, 441, 480, 481, 487, 578*, 644, 658, 1022</td>
</tr>
<tr>
<td>Leung, Daniel</td>
<td>223, 225, 353, 639</td>
</tr>
<tr>
<td>Levat, Robin</td>
<td>416</td>
</tr>
<tr>
<td>Levin, David</td>
<td>678, 679</td>
</tr>
<tr>
<td>Levy, Elliot</td>
<td>319</td>
</tr>
<tr>
<td>Levy, Yair</td>
<td>681</td>
</tr>
<tr>
<td>Lew, Hinboon</td>
<td>1053</td>
</tr>
<tr>
<td>Lewandowski, Robert</td>
<td>3, 56, 81, 83, 86, 89, 267, 268, 269, 291, 313, 359, 432, 541, 546, 548, 549, 550, 562, 1080</td>
</tr>
<tr>
<td>Lewis, Douglas</td>
<td>627*</td>
</tr>
<tr>
<td>Lewis, Sara</td>
<td>176, 212, 336</td>
</tr>
<tr>
<td>Lewis, Spencer</td>
<td>404*</td>
</tr>
<tr>
<td>Lewis, Trevor</td>
<td>622*</td>
</tr>
<tr>
<td>Li, Cheng</td>
<td>505</td>
</tr>
<tr>
<td>Li, Duan</td>
<td>94</td>
</tr>
<tr>
<td>Li, Emily</td>
<td>291</td>
</tr>
<tr>
<td>Li, Guang</td>
<td>99, 434, 529</td>
</tr>
<tr>
<td>Li, Jianke</td>
<td>429</td>
</tr>
<tr>
<td>Li, Jiaying</td>
<td>279</td>
</tr>
<tr>
<td>Li, Li</td>
<td>214</td>
</tr>
<tr>
<td>Li, Ming</td>
<td>213, 219, 1036</td>
</tr>
<tr>
<td>Li, Ning</td>
<td>314</td>
</tr>
<tr>
<td>Li, Peicheng</td>
<td>50*, 576*</td>
</tr>
<tr>
<td>Li, Qiang</td>
<td>50</td>
</tr>
<tr>
<td>Li, Ruizong</td>
<td>71</td>
</tr>
<tr>
<td>Li, Xinhua</td>
<td>76</td>
</tr>
<tr>
<td>Li, Yaying</td>
<td>50, 576*</td>
</tr>
<tr>
<td>Li, Zhenteng</td>
<td>678, 679*</td>
</tr>
<tr>
<td>Liao, Millie</td>
<td>639</td>
</tr>
<tr>
<td>Liao, Zhengyin</td>
<td>531*</td>
</tr>
<tr>
<td>Liapi, Eleni</td>
<td>478*</td>
</tr>
<tr>
<td>Lichliter, Andrew</td>
<td>144</td>
</tr>
<tr>
<td>Liddell, Robert</td>
<td>15, 20, 57, 65, 94, 138, 162, 163, 219, 253, 254, 276, 286, 293, 343, 344, 351, 394, 489, 496, 513, 570, 572, 591, 642, 695</td>
</tr>
<tr>
<td>Lie, Kevin</td>
<td>225, 353</td>
</tr>
<tr>
<td>Lilly, Meghan</td>
<td>1081</td>
</tr>
<tr>
<td>Lim, Marc Michael</td>
<td>605</td>
</tr>
<tr>
<td>Lin, Edward</td>
<td>577*</td>
</tr>
<tr>
<td>Lin, Ethan</td>
<td>182, 259, 512, 1050</td>
</tr>
<tr>
<td>Lin, Hsuan-Hwai</td>
<td>272</td>
</tr>
<tr>
<td>Lin, Jonathan</td>
<td>362</td>
</tr>
<tr>
<td>Lin, Ming De</td>
<td>331, 517</td>
</tr>
<tr>
<td>Lindquist, Jonathan</td>
<td>555</td>
</tr>
<tr>
<td>Lindsay, Thomas</td>
<td>154</td>
</tr>
<tr>
<td>Lionberg, Alex</td>
<td>147</td>
</tr>
<tr>
<td>Lipnik, Andrew</td>
<td>141, 235, 461, 463, 467, 608, 609, 611, 615, 627, 678, 710</td>
</tr>
<tr>
<td>Lithrup, Peter</td>
<td>46, 334</td>
</tr>
<tr>
<td>Liu, Bob</td>
<td>76</td>
</tr>
<tr>
<td>Liu, Chuxu</td>
<td>375</td>
</tr>
<tr>
<td>Liu, Dave</td>
<td>82, 84</td>
</tr>
<tr>
<td>Liu, David</td>
<td>37, 159</td>
</tr>
<tr>
<td>Liu, Jesse</td>
<td>441</td>
</tr>
<tr>
<td>Liu, Li</td>
<td>226</td>
</tr>
<tr>
<td>Liu, Lisa</td>
<td>243, 244*</td>
</tr>
<tr>
<td>Liu, Raymond</td>
<td>126, 551, 602</td>
</tr>
<tr>
<td>Liu, Syrone</td>
<td>15</td>
</tr>
<tr>
<td>Livshits, Ilya</td>
<td>11, 532</td>
</tr>
<tr>
<td>Lo, Richard Hoau</td>
<td>Gong 64</td>
</tr>
<tr>
<td>Loeb, Gabrielle</td>
<td>29*</td>
</tr>
<tr>
<td>Loewenstern,</td>
<td>Joshua 121*, 420*, 532</td>
</tr>
<tr>
<td>Logiurato, Brendan</td>
<td>148</td>
</tr>
<tr>
<td>Lokken, R. Peter</td>
<td>226, 376, 391</td>
</tr>
<tr>
<td>Lombardo, Kara</td>
<td>489</td>
</tr>
<tr>
<td>Longhurst, Colin</td>
<td>48</td>
</tr>
<tr>
<td>Loo, Katherine</td>
<td>339, 392</td>
</tr>
<tr>
<td>Lookestein, Robert</td>
<td>11, 52, 101, 121, 129, 130, 176, 222, 243, 244, 266, 326, 411, 420, 515, 520, 532, 537, 538, 581, 619, 633, 650, 697, 984, 1040</td>
</tr>
<tr>
<td>Lopera, Jorge</td>
<td>173*</td>
</tr>
<tr>
<td>Lopez, Robert</td>
<td>578</td>
</tr>
<tr>
<td>Loree, Howard</td>
<td>408, 423</td>
</tr>
<tr>
<td>Louie, John</td>
<td>41, 88, 124, 128, 365, 369, 376, 391, 504, 513, 516, 523, 525, 531, 697, 712, 1035, 1073</td>
</tr>
<tr>
<td>Lourenco, Pedro</td>
<td>241*</td>
</tr>
<tr>
<td>Loveridge, Kristian</td>
<td>498</td>
</tr>
<tr>
<td>Low, Jason</td>
<td>497</td>
</tr>
<tr>
<td>Lowe, Stephen</td>
<td>108, 434, 710</td>
</tr>
<tr>
<td>Loya, Mohammed</td>
<td>472</td>
</tr>
<tr>
<td>Lu, David</td>
<td>172</td>
</tr>
<tr>
<td>Lu, Jian</td>
<td>163, 1076</td>
</tr>
<tr>
<td>Lu, Shaoeli</td>
<td>489</td>
</tr>
<tr>
<td>Lu, Xiaoning</td>
<td>277</td>
</tr>
<tr>
<td>Lubinski, Alexander</td>
<td>543</td>
</tr>
<tr>
<td>Lubner, Meghan</td>
<td>392</td>
</tr>
<tr>
<td>Ludwig, Johannes</td>
<td>323</td>
</tr>
<tr>
<td>Luellen, David</td>
<td>79</td>
</tr>
<tr>
<td>Lum, Deirdre</td>
<td>1064</td>
</tr>
<tr>
<td>Lungren, Matthew</td>
<td>119</td>
</tr>
<tr>
<td>Lurvey, Robert</td>
<td>684</td>
</tr>
<tr>
<td>Lutz, James</td>
<td>42</td>
</tr>
<tr>
<td>Luyckx, Elisa</td>
<td>202</td>
</tr>
<tr>
<td>Lylyk, Pedro</td>
<td>8</td>
</tr>
<tr>
<td>Lynch, Frank</td>
<td>192</td>
</tr>
<tr>
<td>Lynskey, G. Emmett</td>
<td>85, 134, 273, 278, 540, 564, 1013</td>
</tr>
<tr>
<td>Lyons, Gray</td>
<td>47*</td>
</tr>
</tbody>
</table>

-M-

Macoskey, Jonathan 394*  
Madassery, Sreekumar 158, 380, 698, 1080  
Madhusoodanan, Vinayak 152, 253  
Madoff, David 10, 38, 40, 95, 123, 211, 244, 253, 260, 327, 336, 382, 524, 527, 529, 532, 644, 689  
Mafeld, Sebastian 386, 444*  
Maher, Ben 37*, 82, 84  
Mahmood, Umar 213  
Mahmoud, Khalid 137, 238, 239, 285, 290, 583, 612  
Mähringer-Kunz, Aline 1014  
Mahvash, Armeen 512  
Mai, Andrew 497  
Mailloux, Lionel 484  
Maitra, Neil 708  
Majidi, Shahram 442  
Majumdar, Shamaita 568*, 617*, 640*  
Makary, Mina 463  
Makris, Gregory 635  
Maldonado, Yvonne 295  
Malyutin, Grigoriy 71*  
Man Deuk, Kim 102, 989  
Mandato, Kenneth 427
Mandel, Jacob 258*, 466*, 650*
Mandigo, Grace 29
Maneevese, Michelle 705*
Mani, Naganathan 36, 134, 192, 212, 234, 236, 330, 362, 383, 398, 492, 553, 617, 624, 640, 647, 690, 700, 1045, 1046, 1076
Mankowski-Gettle, Lori 392
Manning, Maria 430
Manov, John 228
Marashi, Keyan 245
Maratto, Sean 433*
Marcelin, Clément 453*
Marcello, Roberto 33, 50, 92, 151, 180, 320, 373, 427, 558, 563, 642, 681, 682
Marcia, Stefano 593*, 1058
Marcus, Sivan 459*
Marinelli, Brett 130*
Marini, Stefano 593, 1058
Marko, Xhorlina 70, 120, 163, 224, 337, 433, 521, 584, 585, 586, 591, 635, 637, 1044, 1055
Marquardt, Steffen 286
Marsh, Robert 436
Martel, Sylvain 314
Martin, Charles 78
Martin, Jonathan 19, 24, 54, 55, 435, 533
Martinez, Nicolas 329, 518
Marcia, Stefano 593*, 1058
Marcus, Sivan 459*
Marinelli, Brett 130*
Marini, Stefano 593, 1058
Marko, Xhorlina 70, 120, 163, 224, 337, 433, 521, 584, 585, 586, 591, 635, 637, 1044, 1055
Marquardt, Steffen 286
Marsh, Robert 436
Martel, Sylvain 314
Martin, Charles 78
Martin, Jonathan 19, 24, 54, 55, 435, 533
Martinez, Nicolas 329, 518
Masada, Tetsuya 281
Maschke, Sabine 286*, 1082
Masi, Gianluca 379
Mason, James 481
Massa, Peter 545*
Massis, Kamal 481
Massoud, Mostafa 281, 290, 583, 612
Massoud, Omar 290
Mathew, Manoj 497
May, Benjamin 74, 148
Maya, Carolina 196*
Maybody, Majid 94*, 117, 254, 574
Maynard, Alex 196*, 254, 383, 408, 438, 459, 468, 644
McBride, Bridgette 641
McCaffrey, Erin 142
McCall, James 686, 690
McConn, Jennifer A. 354
McCoy, David 280
McCorkle, Andrew 632
McDaniel, Janice 252
McDermott, Ailbhe 1027
McDermott, Meredith 39, 40
McDevitt, Joseph 356*
McEnroe, Sarah 74
McGahan, John 684
McKinney, J. Mark 556
McLafferty, Scott 249*
McLaughlin, Shaun 514*
McLennan, Gordon 11, 140, 185, 270, 298, 316, 349, 373, 386, 433, 451, 464, 501, 540, 592, 690, 714, 1000, 1058
McLernon, Eric 611
McPhail, Ian 366, 421, 422
McRae, Stephen 93, 691
Pillai, Rex 465*, 600
Pimpalwar, Sheena 115
Piras, Emanuele 593, 1058
Pisimisis, George 485
Pizarro, Felipe 518
Pizzi, Giuseppe 251*
Plantefève, Rosalie 314
Plemons, John 298
Pless, Miklos 375
Png, Chen Yi Nicholas 381
Poder, Liina 587
Pohlen, Michael 691*
Poliak, Urszula 374, 446, 447, 449
Pollenger, Harrison 131
Ponce-Dorrego, Maria-Dolores 487*
Pohlen, Michael 691*
Polak, Ashwin 257, 561
Postoak, Darren 1074
Potter, Brad 143
Potter, Hollis 203
Potts, Melissa 13, 90
Poundstone, May 309
Pourfathi, Mehrdad 320
Pourhassan Shamchi, Sara 530
Prasad, Vinoy 438
Prat, Aleix 375
Pratt, Daniel 615
Priddy, Erin 13*, 16*, 90*
Priest, Ryan 360, 441
Prigo, Carrie 141
Primmer, Michael 489
Prosser, Dominik 624
Prus, Matthew 46, 334
Pua, Bradley 47
Pua, Uei 46, 179*, 233, 249, 253, 333, 409, 411, 412, 413, 488, 508, 513, 519, 521, 641, 675, 689, 1031
Punnen, Sanoj 985
Purandare, Nilendu 561
Putnam, Samuel 225, 353
Puza, Charles 346*
Pye, Raj 464

-Q-
Qamhawi, Zahi 635
Qazi, Shahbaz 165, 646, 648
Qian, Chenghao 96
Qin, Juan 66*
Qin, Shukui 379
Quinones-Baldrich, William 25

-R-
Rabei, Rana 454*
Rachakonda, Leelanand 618
Raghee, Peter 238, 239, 583
Rahman, Mohammad 410
Rahile, Robert 578
Rais-Bahrami, Soroush 309
Raissi, Driss 96, 171, 1055
Raja, Junaid 261, 345*
Rajan, Anand 463*
Rajan, Dheeraj 62, 63, 154, 158, 191, 192, 234, 453, 557, 561, 568, 630, 637, 700, 715, 1043, 1052
Rajebi, M. Reza 464
Rajeswaran, Shankar 595
Rahman, Hari 647
Raman, Steven 172, 375
Ramaswamy, Raja 36, 247, 283, 299, 324, 363, 461, 480, 553, 568, 585, 588, 613, 617, 640, 647
Ramchandani, Parvati 573
Ranade, Mona 11, 52, 101, 121, 129, 130, 176, 222, 243, 244, 266, 326, 411, 515, 520, 581, 619, 633, 650, 697, 984
Rao, Ramya 230
Rao, Vijay 983
Rasheed, Amer 546*
Rashid, Tariq 605
Reichel, Kent 304, 437
Reis, Joseph 113*, 200*, 362
Reis, Stephen 61, 73, 120, 539, 582, 653, 696
Reisenauer, Chris 310, 361
Rennie, Julius 286
Rensnick, Scott 308, 630, 634
Revel-Mouroz, Paul 385, 409
Reynolds, David 591
Rhone, Jerrika 478
Riaz, Absun 3, 81, 83, 86, 89, 267, 268, 269, 291, 432, 541, 546, 548, 549*, 550, 562
Riaz, Rehan 380
Rice, Samuel 552*, 700*
Richard, Howard 2, 18, 19, 52, 61, 92, 95, 153, 170, 171, 194, 358, 431, 490, 494, 498, 985, 988, 1081
Richards, Masters 209*, 586
Richardson, Andrew 10*, 666
Richardson, Baxter 675*
Richardson, J. Scott 408, 423
Riedl, Christopher 264
Riesen, Jenny 194
Rilling, William 709
Rishi, Anupam 693
Rivard, Douglas 708
Rivera, Victor 277
Rivera-Sanfeliz, Gerant 19, 159, 229, 236, 260, 508, 553, 557, 567, 636, 1049
Rizk, Michael 46, 334
Roberts, John 271, 525
Robertson, Taylor 660
Robinson, Amie 708
Robinson, Gina 75
Rochon, Matthew 250*
Rochon, Paul 28, 29, 57, 190, 208, 354, 357, 410, 435, 458, 467, 485, 555, 638, 985, 986, 1082, 1085
Ronald, James 123, 188, 198, 390, 627, 702
Rose, Steven 133
Rosenberg, Michael 655
Sarah, Connelly 299
Sarin, Shawn 442*, 682, 987, 1073
Sarin, Shiv 289
Sark, Monika 525
Sarkar, Debkumar 687
Sarwar, Ammar 622
Sasson, Talia 362
Sato, Takeshi 281
Sato, Yozo 563
Savin, Lynn 337, 517
Savin, Jeffrey 544
Savin, Michael 39, 56, 125, 194, 214, 254, 328, 336, 367, 393, 395, 510, 539, 544, 547, 548, 620, 632, 651, 658, 693, 715
Sayegh, Samia 479
Sayre, James 388
Scagnelli, Thomas 139, 654
Schaaps, Nicole 1002
Schaefer, Carrie 594
Schaefer, Matthew 231
Schainfeld, Robert 455
Scheffler, Hester J 393
Scheiner, Jonathan 995
Scheinkman, Brian 143
Schenning, Ryan 146, 624, 1077
Scher, Daniel 682, 1073
Schneierlein, Katie 709
Schiffman, Marc 417
Schild, Hans 68, 559, 1049
Schiro, Brian 70, 120, 163, 224, 337, 433, 521, 584, 585, 586, 591, 635, 637, 1044, 1055
Schlachter, Todd 517
Schlansky, Barry 287
Schlossberg, Peter 73, 120
Schmitz-Rode, Thomas 1002
Schoolley, Mary 620
Schotten, Sebastian 476*, 1014
Schramm, Kristofer 555
Schultz, Susan 32, 528
Schwartz, Jon 212, 336
Schwartz, Scott 4, 144, 167, 171, 188, 203, 225, 266, 268, 300, 341, 375, 376, 392, 417, 464, 545, 548, 606, 625, 654, 1076
Scipio, Danien 284
Scott, Evan 317
Scott, Kelly 580
Secrist, Michael 53
Sehgal, Chandra 32, 528
Seifahadi, Reza 652, 1079
Sella, David 556
Sellers, Cortlandt 323*
Seo, Tae-Seok 668, 683, 689, 699
Seraj, Siyamak 398
Sema, Juan 288*
Serrano Casorran, Carolina 169, 229
Serulle, Yafell 674
Sethi, Ashish 152*
Sfakianos, John 336
Shabrang, Cyrus 370, 499, 624
Shah, Jay 435*, 533*
Shah, Jehan 543*, 1074
Shah, Ketan 550
Shah, Kumar 103
Shah, Kush 654*
Shah, Neil 58
Shah, Raj 142*
Shah, Rajesh 30, 36, 172, 244, 293, 297, 330, 393, 471, 498, 509, 679, 1024, 1033
Shah, Sneha 551
Shahrouki, Puja 25*
Shahverdiani, Ali 15
Shaikh, Raja 260*, 604*, 664
Shaikh, Shehzad 7
Shaked, Abraham 557
Shaktman, Barry 417
Shamimi-Noori, Susan 270, 296
Shao, Guoliang 511*
Shapiro, Oleg 570, 572
Sharma, Ashwani 15
Sharma, Manish 147
Sharma, Pranav 703*
Sharma, Sanjiv 1*
Shaughnessy, Gabe 190
Shaw, Cathryn 70
Shaw, Dennis 116, 596
Shawali, Islam 238, 239, 583
Shay, Wesley 574*
Sheehan, J 1027
Sheeran, Daniel 58, 208, 657
Shen, Jian 275*
Shen, Tao 429
Sheppard, Declan 1027
Sheerzad, Afsheen 27
Sheth, Rahul 51, 91, 259, 282, 338*, 371, 396, 446, 485, 501, 523, 608, 625, 691, 1028, 1050
Sheth, Sunil 51, 91, 282, 501, 625, 1028
Shetty, Nitin 257
Shetty, Nitin Sudhakar 561
Sheu, Alexander 297*, 471
Shemyzon, Vladimir 73, 120
Shi, Hongjian 429*
Shi, Jiaqi 394
Shiau, Maria 97
Shi, Jiaqi 394
Shields, James 567
Shih, Yu-Lueng 272, 378
Shilo, Dan 411, 619
Shin, Jong Joon 672*
Shin, Benjamin 573*
Shin, David 87*
Shin, Eun Ji 104
Shin, Sung Wook 138, 645
Shirono, Ryozo 694
Shivaram, Giri 112*, 116, 119, 596
Shlansky-Goldberg, Richard 62, 288, 557
Shlomovitz, Eran 1046
Shoaib, Obaib 11*, 532
Shoela, Ramy 640
Shoreibah, Mohamed 290
Shrestha, Prashant 620
Shrestha, Roshan 131
Shreave, Lauren 616*
Shreyak, Sai 1075
Srikhande, Shailesh 561
Shrivastava, Amit 1053
Shukla, Pratik 101*, 129, 212*, 336*, 566*, 650
Shulman, Adina 74
Siddiqui, Efaza 456*, 707
Sideris, George 478
Sidhu, Devinder (Ruby) 408, 423
Sidor, Alexander 500
Siegelbaum, Robert 94
Sienko, Danielle 26
Sierke, Sergio 6, 111, 113, 115, 116, 117, 252, 421, 433, 454, 595, 596, 708, 1059
Sigounas, Dimitri 442
Sikander, Sakura 211
Silberzweig, James 71, 297, 462, 616, 623, 663
Silin, Douglas 460
Silk, Mikhail 316*, 348
Simon, Nicole 1050
Singer, Samuel 258
Singh, Arvind 577
Singh, Kamalpreet 20
Singh, Karan 544
Singh, Manu 326*, 581*
Sinha, Vishal 4*, 5*, 7*, 9*, 10, 184, 426*, 985
Siskin, Gary 427
Sivaraman, Arjun 349
Skummer, Philip 191, 193, 195, 197, 570, 572
Smirniotopoulos, John 148, 417*
Smith, Dylan 14, 418
Smith, Jacob 116
Smith, Johanna 402, 693
Smith, Tony 198, 627
Smolock, Amanda 67*, 333*, 339*, 392*, 557
Sniderman, Kenneth 70, 154*, 610*
Soares, Gregory 680
Sobolevsky, Sergei 687
Sofocleous, Constantinos 94, 254, 264, 322, 328, 340
Solomon, Alex 311
Solomon, Stephen 2, 94, 117, 254, 325, 328, 340, 349, 448, 1035
Som, Avik 283, 363*, 461*, 585*
Song, Ho-Young 571, 1052
Song, Myung-Gyu 683*, 689, 699*
Song, Sang-Eun 211*
Song, Tianqiang 379
Sood, Rishi 682*, 987
Sopko, David 198, 368
Sosner, Eitan 479
Sosnov, Jonathan 79
Sotiriadis, Dimitrios 478
Soun, Michael 41, 265*, 270, 288, 333, 341, 496, 530, 1000
Soulez, Gilles 314
Speir, Eitan 24*
Sperling, David 73, 582, 694
Spies, James 85, 134, 273, 278, 311, 430, 540
Spiliopoulos, Stavros 236, 237
Spinelli, Alessio 593, 1058
Springer, Joseph 713
Sridhar, Divya 500
Srinathveeravalli, Govindarajan 2, 321, 349, 448, 450
Srinivasan, Rajiv 419*, 567*, 598
Srinivasan, Ravi 9, 70, 83, 168, 199, 221, 263, 267, 283, 345, 352, 356, 391, 404, 419*, 470, 496, 525, 528, 533, 565, 567*, 574, 584, 589, 598*, 621, 657, 708
Srinivasan, Abhay 196, 1059
Stalnken, Brian 47, 68, 87, 103, 154, 207, 256, 259, 372, 386, 539, 554, 557, 566, 707, 1040, 1057
Stampe, Christopher 586*
Stanek, Agatha 1053
Stark, Christopher 427
Stavropoulos, S. William 41, 57, 270, 288, 333, 530, 557
Ste. Marie, Janet 709
<table>
<thead>
<tr>
<th>Name</th>
<th>Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Werncke, Thomas</td>
<td>286</td>
</tr>
<tr>
<td>Werner, John</td>
<td>141, 343, 344</td>
</tr>
<tr>
<td>Werner, John</td>
<td>276</td>
</tr>
<tr>
<td>Westrich, Geoffrey</td>
<td>203</td>
</tr>
<tr>
<td>White, Eric</td>
<td>14, 418</td>
</tr>
<tr>
<td>White, Sarah</td>
<td>194, 297, 455, 524, 543, 606, 608, 676, 709, 1064</td>
</tr>
<tr>
<td>Whittle, Bryan</td>
<td>127</td>
</tr>
<tr>
<td>Wholey, Michael</td>
<td>42</td>
</tr>
<tr>
<td>Widdicombe, Joseph</td>
<td>164</td>
</tr>
<tr>
<td>Widemon, Reginald</td>
<td>61*, 539, 696</td>
</tr>
<tr>
<td>Wiggermann, Philipp</td>
<td>688</td>
</tr>
<tr>
<td>Wiggins, Ernest</td>
<td>502</td>
</tr>
<tr>
<td>Wildenberg, Joseph</td>
<td>149, 342, 496</td>
</tr>
<tr>
<td>Wiley, Sean</td>
<td>543</td>
</tr>
<tr>
<td>Wilkins, Luke</td>
<td>58, 153, 208, 464, 657</td>
</tr>
<tr>
<td>Will, Alice</td>
<td>59</td>
</tr>
<tr>
<td>Willard, Scott</td>
<td>594*</td>
</tr>
<tr>
<td>Williams, David</td>
<td>105, 148, 220, 317, 353, 415, 443, 452, 480, 485, 636, 637, 639, 670, 1077</td>
</tr>
<tr>
<td>Wilson, Mark</td>
<td>107, 459</td>
</tr>
<tr>
<td>Wilson-Flewelling, Scott</td>
<td>28</td>
</tr>
<tr>
<td>Windham-Herman, Austin-Mary</td>
<td>331, 517</td>
</tr>
<tr>
<td>Winkler, Michael</td>
<td>96, 1055</td>
</tr>
<tr>
<td>Winoker, Jerod</td>
<td>212, 336</td>
</tr>
<tr>
<td>Winokur, Ronald</td>
<td>47, 644</td>
</tr>
<tr>
<td>Wiseman, Daniele</td>
<td>248</td>
</tr>
<tr>
<td>Witting, Avery</td>
<td>220, 406, 452</td>
</tr>
<tr>
<td>Wolf, Frederic</td>
<td>1002</td>
</tr>
<tr>
<td>Won, Je Hwan</td>
<td>672, 676, 677</td>
</tr>
<tr>
<td>Won, Jong Yun</td>
<td>102*, 671, 989</td>
</tr>
<tr>
<td>Wong, Ching-yee</td>
<td>544</td>
</tr>
<tr>
<td>Wong, Florence</td>
<td>70, 610</td>
</tr>
<tr>
<td>Wong, Jason</td>
<td>186, 655</td>
</tr>
<tr>
<td>Wong Kant, Sikiya</td>
<td>169</td>
</tr>
<tr>
<td>Wood, Christopher</td>
<td>242</td>
</tr>
<tr>
<td>Woodhead, Gregory</td>
<td>227</td>
</tr>
<tr>
<td>Woods, David</td>
<td>319</td>
</tr>
<tr>
<td>Woods, Michael</td>
<td>303</td>
</tr>
<tr>
<td>Workman, Stephanie</td>
<td>383</td>
</tr>
<tr>
<td>Worlikar, Tejaswi</td>
<td>495*</td>
</tr>
<tr>
<td>Wu, Bei</td>
<td>526</td>
</tr>
<tr>
<td>Wu, Carol</td>
<td>485</td>
</tr>
<tr>
<td>Wu, Hanping</td>
<td>315*</td>
</tr>
<tr>
<td>Wu, Linda</td>
<td>626</td>
</tr>
<tr>
<td>Wu, Vincent</td>
<td>455*</td>
</tr>
<tr>
<td>Wu, Xia</td>
<td>401, 508</td>
</tr>
<tr>
<td>Wunderle, Kevin</td>
<td>78</td>
</tr>
</tbody>
</table>

**-X-**

- Xi, Wei 526
- Xia, Yan 510
- Xiao, Nicholas 56*
- Xu, David 539, 696*
- Xu, Jimmy 397
- Xu, Perry 6
- Xu, Qiang 429
- Xu, Sheng 170*, 213, 215, 219, 1036
- Xu, Zhen 339, 392, 394, 495
- Xue, Jingbing 362

**-Y-**

- Yablonsky, Thaddeus 410
- Yadav, Amitabh 703
- Yamada, Kei 615
- Yamada, Koichiro 205
- Yamada, Ricardo 216*
- Yamakado, Koichiro 445, 643
- Yamanaka, Takashi 492
- Yamashita, Suguru 396
- Yamaura, Hidekazu 563
- Yan, Feng 526
- Yan, Zihao 575
- Yang, Biao 531
- Yang, Gaoyi 706
- Yang, Ginger 519
- Yang, Kai 76
- Yang, Woo Jin 636, 637*
- Yang, Xiaoming 50, 576
- Yang, Yihe 548, 549
- Yao, Francis 280
- Yao, Francis 271
- Yarmohammadi, Hooman 94, 117, 258, 264, 325, 328, 340, 552, 1035
- Yassan, Lindsay 317
- Yasumoto, Taku 205*
- Yen, Lawrence 21
- Yevich, Steven 51, 259, 282, 396, 485, 625
- Yi, Jung Woo 685, 701
- Yi, Paul 30, 300, 406, 474*
- Yi, Sijia 317
- Yim, Jaehyun 645
- Yin, Xi 580
- Ying, Guo-wen 526
- Ying, Shihong 401, 506
- Yokosuka, Osamu 379
- Yoo, Raphael 111*
- Yoon, Hyukjung 322
- Yoon, Hyun-Ki 636, 637
- Yoon, Jessica 430*
- Yoshida, Emi 43, 49
- Yoshida, Takegawa 25
- Young, Shamar 364, 586, 614*, 620, 655*
- Young, Victoria 359*, 562*
- Yu, Daohai 277
- Yu, Hui 526*
- Yu, Hyeon 307, 632
- Yu, Wenqiang 511
- Yu, Xiaoling 429
- Yu, Xinge 100
- Yuen, Alexander 110, 172
- Yun, Jong Hyouk 161*

**-Z-**

- Zech, John 1040
- Zener, Rebecca 322*, 1046
- Zenobi, Christina 94
- Zhang, Diaobo 191, 193, 195, 570, 572
- Zhang, Edwin 367
- Zhang, Feng 50, 576
- Zhang, Jian 505
- Zhang, Jie 1055
- Zhang, Jing-yuan 526
- Zhang, Jinjin 377
- Zhang, Kan 641*
- Zhang, Rhongzhen 503
- Zhang, Shunqing 191*, 193*, 195, 197
- Zhang, Xi 394
- Zhang, Xiang 149
- Zhang, Yachao 605*
- Zhang, Yuelin 329, 507
Zhang, Zhuoli 350
Zhang, Zi 230*
Zhao, Dan 706*
Zhao, Liangcai 50, 576
Zhao, Shuhui 576
Zheng, Hui 76
Zhong, Bin-Yan 38*, 163, 170
Zhou, Bin 526
Zhou, Guanhui 135, 329, 507, 511
Zhou, Hai-Feng 163*
Zhou, Minerva 247*
Zhou, Royce 532
Zhou, Tanyang 329, 507
Zhou, Xianyong 506
Zhou, Yiming 50, 576
Zhu, Andrew 175
Zhu, Hai-Dong 66, 163, 170
Zhu, Tongyin 329, 507
Zhu, Xiaoli 275
Zhu, Yunxiao 317
Zhuang, Kun Da 64, 157*, 381*
Ziegler, Cole 702*
Ziemlewicz, Timothy 339, 392
Zinsmeister, Christopher 21
Ziv, Etay 94, 258, 264, 322, 325*, 328, 1035
Zolet, Morris 75
Zuckerman, Darryl 12, 37, 81, 107, 133, 171, 174, 216, 317, 339, 347, 396, 398, 414, 420, 515, 575, 632, 689, 714, 988
Zurkiya, Omar 126, 175
Zvavanjanja, Rodrick 497*, 503*
Zwiebel, Bruce 483, 618
Zybulewski, Adam 515*, 566
When you ask doctors who have used the AngioVac System about their experience, their passion is clear. That’s because the results can be dramatic.1 The AngioVac Cannula and Circuit from AngioDynamics—for the removal of fresh, soft thrombi or emboli in target vessels, such as the iliofemoral veins, inferior vena cava, superior vena cava and right atrium.

A picture is worth a thousand words

When you ask doctors who have used the AngioVac System about their experience, their passion is clear. That’s because the results can be dramatic.1 The AngioVac Cannula and Circuit from AngioDynamics—for the removal of fresh, soft thrombi or emboli in target vessels, such as the iliofemoral veins, inferior vena cava, superior vena cava and right atrium.

The results can be dramatic.1
Learn more at AngioVac.com.

1Results from a case study are not predictive of results in other cases. Results in other cases may vary.
INDICATION FOR USE: The Solero Microwave Tissue Ablation (MTA) System and Accessories are indicated for the ablation of soft tissue during open procedures. The Solero MTA System is not intended for cardiac use. Please refer to the Solero Generator Operator’s Manual and the Solero Applicator Directions For Use for complete instructions, warnings, and precautions. CAUTION: Federal Law (USA) restricts this device to sale by or use under the order of a physician.

*AngioDynamics, the AngioDynamics logo, Solero, and the Solero logo are trademarks and/or registered trademarks of AngioDynamics, Inc., an affiliate or subsidiary. © 2017 AngioDynamics, Inc. ANGAD 355 US Rev 01 12/17

www.angiodynamics.com

The single applicator system with the ability to complete up to a 5 cm ablation in 6 minutes†

− Dielectric Antenna with an Optimized Ceramic Tip
− Patented Coolant Channel with Thermocouple
− 2.86 m (9.3 ft) Flexible, Fully Cooled Cable
− 15 g Stainless Steel Applicator
− Available in 14, 19, and 29 cm Lengths

† Ex vivo bovine liver- actual clinical results in perfused tissues may differ