

Journal of  
2016 **Ultrasound**  
in Medicine

The multidisciplinary medical ultrasound journal

A detailed, light blue map of New York City serves as the background for the lower half of the cover. It shows the dense grid of streets in Manhattan, with labels for various neighborhoods and landmarks. The map is oriented with North at the top.

# Official Proceedings

AMERICAN INSTITUTE OF ULTRASOUND IN MEDICINE

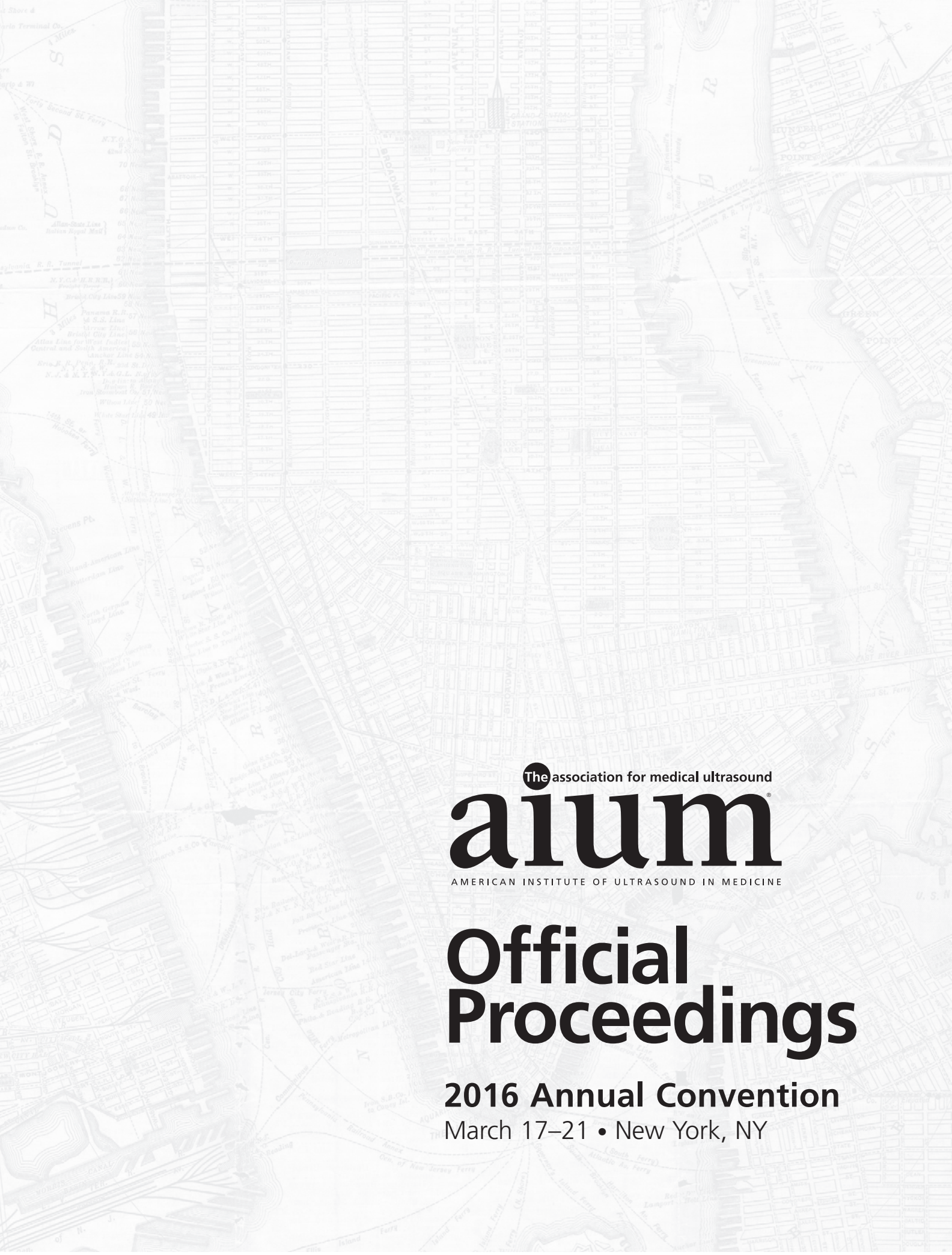
## Annual Convention

March 17–21 • New York, NY

The official journal of the  
**aium**<sup>®</sup>  
AMERICAN INSTITUTE OF ULTRASOUND IN MEDICINE

[www.jultrasoundmed.org](http://www.jultrasoundmed.org) • [www.aium.org](http://www.aium.org)





The association for medical ultrasound

**aium**<sup>®</sup>

AMERICAN INSTITUTE OF ULTRASOUND IN MEDICINE

# Official Proceedings

**2016 Annual Convention**

March 17–21 • New York, NY

# Table of Contents

## 2016 AIUM Award Winners

William J. Fry Memorial Lecture Award .....	iii
Joseph H. Holmes Basic Science Pioneer Award .....	iv
Joseph H. Holmes Clinical Pioneer Award .....	v
Peter H. Arger Excellence in Medical Student Education Award .....	vi
Distinguished Sonographer Award .....	vii
Honorary Fellow Awards.....	viii
Memorial Recognition .....	x
Endowment for Education and Research Donors .....	xii

## 2016 Scientific Sessions

### SATURDAY, MARCH 19, 2016

---

#### *Scientific Sessions, 11:00 AM–12:30 PM*

Basic Science: Bioeffects and Instrumentation .....	S3
Cardiovascular Ultrasound.....	S4
Obstetric Ultrasound: Fetal Anomalies .....	S7
Point-of-Care Ultrasound.....	S11

#### *Scientific Sessions, 4:00 PM–5:30 PM*

Elastography .....	S15
Musculoskeletal Ultrasound .....	S17
Obstetric Ultrasound: Uterus, Placenta, and Cervix .....	S18
Therapeutic Ultrasound .....	S21

### SUNDAY, MARCH 20, 2016

---

#### *Scientific Sessions, 11:00 AM–12:30 PM*

Basic Science: Tissue Characterization .....	S25
Breast Ultrasound .....	S26
Contrast-Enhanced Ultrasound.....	S28
General, Abdominal, and Interventional-Intraoperative Ultrasound .....	S31
New Investigator Session .....	S34
Obstetric Ultrasound: New Techniques .....	S38
Point-of-Care Ultrasound.....	S41
Ultrasound in Medical Education .....	S45

#### *Scientific Sessions, 4:00 PM–5:30 PM*

Elastography .....	S48
Gynecologic Ultrasound.....	S51
High-Frequency and Contrast-Enhanced Ultrasound .....	S56
Pediatric Ultrasound and Neurosonology .....	S57

### MONDAY, MARCH 21, 2016

---

#### *Scientific Sessions, 11:00 AM–12:30 PM*

Contrast-Enhanced Ultrasound.....	S59
Fetal Echocardiography .....	S61
Obstetric Ultrasound: Fetal Growth .....	S64

## E-Posters

Basic Science and Instrumentation .....	S68
Cardiovascular Ultrasound .....	S70
Contrast-Enhanced Ultrasound .....	S71
Elastography .....	S73
Emergency and Critical Care Ultrasound .....	S74
Fetal Echocardiography .....	S91
General and Abdominal Ultrasound: Breast .....	S91
General and Abdominal Ultrasound: General .....	S92
General and Abdominal Ultrasound: Urinary Tract .....	S95
Gynecologic Ultrasound .....	S95
High-Frequency Clinical and Preclinical Imaging .....	S99
Interventional-Intraoperative Ultrasound .....	S100
Musculoskeletal Ultrasound .....	S101
Obstetric Ultrasound: Fetal Anomalies .....	S106
Obstetric Ultrasound: Fetal Growth .....	S110
Obstetric Ultrasound: General .....	S111
Obstetric Ultrasound: New Techniques .....	S115
Obstetric Ultrasound: Uterus, Placenta, and Cervix .....	S116
Pediatric Ultrasound .....	S116
Sonography: Education and Training .....	S117
Sonography: Practice Management .....	S122
Therapeutic Ultrasound .....	S122
 Continuing Medical Education Credit Information .....	 S123
Disclosures From AIUM Officers, Board Members, Committee Members, and AIUM Staff .....	S124
Faculty Disclosures .....	S125
Disclosure of Commerical Support for the 2016 AIUM Annual Convention .....	S126
Index .....	S127

## General Information

### Subscription Rates

*Journal of Ultrasound in Medicine* (ISSN 0278-4297) is issued monthly by the American Institute of Ultrasound in Medicine, 14750 Sweitzer Ln, Suite 100, Laurel, MD 20707-5906 USA. Subscription prices per year: institution \$573 (online only) or \$610 (print + online); individual \$380 (print + online). Canada and Mexico please add \$50. Outside the United States, Canada, and Mexico please add \$65. Claims for missing issues, made within 6 months of the issue date, can be honored through contact with the AIUM Executive Office. The AIUM shall be responsible for the cost of resending the claimed issue(s) 1 time. Should the issue(s) be claimed a second time, the shipping and handling costs shall be the responsibility of the subscriber/member (\$8 US; \$26 International). After 6 months, printed issues will be available at the back issue price for a limited time based on inventory, or the issue may be accessed online. Duplicate copies will not be sent to replace ones undelivered through failure to notify the American Institute of Ultrasound in Medicine of a change of address. Single copy and back volume information, available from the American Institute of Ultrasound in Medicine, upon request. Periodicals postage paid at Laurel, MD, and additional mailing offices.

Postmaster: Send address changes to *Journal of Ultrasound in Medicine*, American Institute of Ultrasound in Medicine, 14750 Sweitzer Ln, Suite 100, Laurel, MD 20707-5906 USA.

Printed in the USA. This journal is printed on acid-free paper.

### Manuscripts, Membership, and Business Matters

Correspondence should be addressed to the American Institute of Ultrasound in Medicine, 14750 Sweitzer Ln, Suite 100, Laurel, MD 20707-5906 USA; phone: 301-498-4100. Information on membership can be found at [www.aium.org](http://www.aium.org).

The *Journal of Ultrasound in Medicine* is indexed/abstracted in *Index Medicus*, *Current Contents/Clinical Medicine*, *EMBASE/Excerpta Medica*, *Science Citation Index Expanded*, *ISI Alerting Service*, *Engineering Information*, *MEDLINE*, *Medical Documentation Service*, and *RSNA Index to Imaging Literature*.

### Advertising

Inquiries should be addressed to Advertising Sales, American Institute of Ultrasound in Medicine, 14750 Sweitzer Ln, Suite 100, Laurel, MD 20707-5906 USA; phone: 301-498-4100.

The appearance of advertising in publications of the American Institute of Ultrasound in Medicine (and/or exhibits at meetings of the Institute) does not constitute a guarantee or endorsement of the quality or value of such product or of the claims made for it by its manufacturer. The fact that a product, service, or company is advertised in a publication of the American Institute of Ultrasound in Medicine shall not be referred to by the manufacturer in collateral advertising.

© 2016 by the American Institute of Ultrasound in Medicine

This journal has been registered with the Copyright Clearance Center, Inc. Consent is given for the copying of articles for personal or internal use, or for the personal or internal use of specific clients. This consent is given on the condition that the copier pay through the Center the per-copy fee listed online at [www.copyright.com](http://www.copyright.com) for copying beyond that permitted by the US Copyright Law. This consent does not extend to other kinds of copying, such as for general distribution, resale, advertising and promotional purposes, or for creating new collective works.

American Institute of Ultrasound in Medicine  
14750 Sweitzer Ln, Suite 100 • Laurel, MD 20707-5906 USA  
[www.aium.org](http://www.aium.org) • [julttrasoundmed.org](http://julttrasoundmed.org)



# 2016 AIUM Award Winners

## William J. Fry Memorial Lecture Award

---

*The William J. Fry Memorial Lecture Award was established by Joseph H. Holmes, MD, in 1969 and presented for the first time at the AIUM Annual Convention in Winnipeg that year. William J. Fry was a physicist with a strong interest in ultrasound in medicine, whose innovative research efforts advanced the field of medical ultrasound. One of Prof Fry's most notable contributions was the successful design of an ultrasonic system used to pinpoint lesions in the brain without damaging adjacent tissues. This ultrasonic system was later used to treat various brain pathologies and, in particular, Parkinson disease. His impassioned interest in ultrasound led him to become president of the AIUM from 1966 until his death in 1968. The following year, the William J. Fry Memorial Lecture Award was established in his honor. It recognizes a current or retired AIUM member who has significantly contributed in his or her particular field to the scientific progress of medical ultrasound.*

## Dirk Timmerman, MD, PhD, FRCOG



The AIUM's most prestigious award—the William J. Fry Memorial Lecture Award—is rightly presented this year to a most prestigious physician. Dirk Timmerman, MD, PhD, FRCOG, a native of Belgium, is a full professor in obstetrics and gynecology at the University of Leuven (known commonly as KU Leuven) and clinical head of benign gynecology and gynecological ultrasound at the University Hospitals Leuven. He graduated from medical school (summa cum laude) in 1989 and

subsequently served as registrar in obstetrics and gynecology at Watford General Hospital in the United Kingdom and University Hospitals Leuven until he became a specialist and consultant in obstetrics and gynecology at the University Hospitals Leuven.

Not content with just a medical degree, Dr Timmerman defended his doctoral thesis in 1997, titled “Ultrasonography in the Assessment of Ovarian and Tamoxifen-Associated Endometrial Pathology.” Thus, he continued his impressive career in gynecologic ultrasound, early pregnancy and miscarriage, and the detection and staging of gynecologic cancers—and women across the globe are significantly better for his commitment.

Dr Timmerman is founder and coordinator of the International Ovarian Tumor Analysis Group, whose aims include the development of new algorithms to detect ovarian cancer, as well as optimal care of patients with adnexal tumors. There are currently 40+ centers throughout the world that are part of this collaborative effort, which has the potential to have such a positive impact on so many women from all strata and from all geographic locations

His service as past editor of *Ultrasound in Obstetrics and Gynecology* and reviewer for 20 international journals are just small indications of his interest in imparting the latest and best information to all clinicians. In 2012, his nomination was approved to the International Advisory Board of *The Obstetrician & Gynaecologist (TOG)*, which is the journal for continuing professional development of the Royal

College of Obstetricians and Gynaecologists (RCOG), and in 2013, he became an associate editor of *TOG*. In addition, Dr Timmerman has coauthored more than 300 journal articles and been a presenter 400+ times at international meetings.

A board member of the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) for multiple terms, Dr Timmerman has also been a member of ISUOG's Scientific Committee since 2013. He is a member of the Medical Council of UZ Leuven, former chair of the Clinical Research Fund of the University Hospitals Leuven, president of the Flanders Ultrasound Society, and senior clinical investigator of the Scientific Research Fund Flanders, which partly releases him from clinical duties to perform more clinical research.

In 2014, Dr Timmerman was awarded the InBev Baillet-Latour Prize for Clinical Research by Her Majesty the Queen of the Belgians at the Royal Academy of Medicine for his multicenter study of computer models for diagnosis of ovarian tumors, work that has already changed international clinical guidelines. Also in 2014, RCOG bestowed on him the status of Fellow ad eundem, which is awarded to individuals who have demonstrated, through research or clinical commitment, major contributions to obstetrics, gynecology, or reproductive health, have contributed to the advancement of the science or practice of obstetrics and gynecology in a substantial way, and are of an extremely high scientific caliber. We think RCOG has described Dr Timmerman to a T.

### **Lecture Topic: *Tips and Tricks of Successful Ultrasound Studies***

This lecture will cover lessons learned from 20 years of clinical research in gynecologic ultrasound ranging from assessment of ovarian tumors and uterine pathology to complications in early pregnancy.

# 2016 AIUM Award Winners

## Joseph H. Holmes Basic Science Pioneer Award

---

*The Pioneer Award, which honors an individual who has significantly contributed to the growth and development of medical ultrasound, was established in 1977. This special award was renamed in 1982 to honor Joseph H. Holmes, MD, who died that year. Dr Holmes, the first person named as an AIUM pioneer, was an important figure to both the field of diagnostic ultrasound and the AIUM. His early efforts in ultrasound research, which included tissue characterization and ultrasound's diagnostic use in polycystic kidney disease and orthopedics, helped advance the field of ultrasound and encourage others to conduct new research. Serving the AIUM in many capacities, Dr Holmes was president from 1968 to 1970 and was editor of the AIUM's official journal, which was then titled the Journal of Clinical Ultrasound, for nearly 10 years. Each year, the Joseph H. Holmes Pioneer Award honors 2 current or retired members: 1 in clinical science and the other in basic science.*

## Michael Kolios, PhD



In 1997, Michael Kolios, PhD, was an assistant professor in the Department of Mathematics, Physics, and Computer Science at Ryerson University in Toronto, Canada. From day 1, Ryerson University realized what an incredible asset Dr Kolios was and has never let him go. Today he is a tenured professor in the Department of Physics and associate dean of research and graduate studies, Faculty of Science, as well as an affiliate scientist at St Michael's Hospital in Toronto. Dr Kolios earned his bachelor's degree in physics from the

University of Waterloo, followed by master's and doctoral degrees at the University of Toronto, Department of Medical Biophysics.

He has been winning awards since his undergraduate days, and as a faculty member receiving the Ontario Premiers' Early Researcher Award and a Canada Research Chair in Biomedical Applications of Ultrasound. His most recent award is the Sarwan Sahota Distinguished Scholar Award, which is presented to faculty who have made an outstanding contribution to knowledge in their area of expertise, and there certainly could not have been a more deserving candidate. With 5 patents and another 3 provisional patents to his name, Dr Kolios—whose calendar age puts him the toddler category in comparison to other professional researchers—is taking the ultrasound science world by storm and setting an example that will be difficult for his juniors to achieve and for his seniors to match.

One of the many attributes that sets Dr Kolios apart is his commitment to education at all levels. He has supervised a total of 16 doctoral candidates, as well as 29 master-of-science students, which would keep most people busy enough, but Dr Kolios has also supervised a dozen undergraduate students and 25 research assistants and has been involved in promoting science among high school students through programs such as the Sanofi-Aventis BioTalent Challenge, the Dragon Academy Scientists-in-Action program, and Ryerson's Research Opportunity Program in Engineering. There is no doubt that due to his exceptional tutelage, the people whom he has taken under his wing will be making significant contributions to medical ultrasound in the future—a legacy that anyone would envy.

A reviewer for more than 15 scholarly journals, Dr Kolios is on the editorial boards of *Ultrasonic Imaging* and *Photoacoustics* and has served as an abstract reviewer for more than 10 professional conferences. He regularly reviews for the Canadian Institutes of Health Research and is a charter member of the National Institutes of Health Biomedical Imaging Technology Study Section. Recognized for his exceptional research skills, he has served as project leader, principal investigator, or coinvestigator on close to 60 projects with the potential for a significant impact on technology, cancer, bioengineering, and health care. Dr Kolios has 5 book chapters to his name, has published 80 articles in peer-reviewed journals, has 100+ papers in national and international conference proceedings, and has presented 150+ papers or abstracts at conferences throughout Canada, the United States, and Europe.

He has been an active member of the AIUM's Bioeffects Committee and twice chair of the AIUM's High-Frequency Clinical and Preclinical Imaging Community, as well as a long-term member of the Institute of Electrical and Electronics Engineers International Ultrasound Symposium Technical Program Committee, to name just a few of his leadership positions.

Dr Joseph Holmes was certainly innovative and a pioneer, but he probably never imagined in his wildest dreams how far someone like Dr Kolios would advance the science of ultrasound and how he would set the stage for future pioneers.

# 2016 AIUM Award Winners

## Joseph H. Holmes Clinical Pioneer Award

*The Pioneer Award, which honors an individual who has significantly contributed to the growth and development of medical ultrasound, was established in 1977. This special award was renamed in 1982 to honor Joseph H. Holmes, MD, who died that year. Dr Holmes, the first person named as an AIUM pioneer, was an important figure to both the field of diagnostic ultrasound and the AIUM. His early efforts in ultrasound research, which included tissue characterization and ultrasound's diagnostic use in polycystic kidney disease and orthopedics, helped advance the field of ultrasound and encourage others to conduct new research. Serving the AIUM in many capacities, Dr Holmes was president from 1968 to 1970 and was editor of the AIUM's official journal, which was then titled the Journal of Clinical Ultrasound, for nearly 10 years. Each year, the Joseph H. Holmes Pioneer Award honors 2 current or retired members: 1 in clinical science and the other in basic science.*

## Alfred Abuhamad, MD, FAIUM



Physician, educator, inventor, and humanitarian—Alfred Abuhamad, MD, FAIUM, is not a man who can be described with just one word. A graduate of the American University of Beirut Medical School in Lebanon, he interned and completed his residency in obstetrics and gynecology at the University of Miami School of Medicine, followed by a fellowship at the same institution and another fellowship in ultrasound and prenatal diagnosis at Yale University. His exceptional expertise in ultrasound resulted

in his appointment in 1992 as the director of ultrasonography at the Eastern Virginia Medical School, where he has remained ever since. Currently, he is the vice dean for clinical affairs, chair of the Department of Obstetrics and Gynecology, professor of radiology, and the Mason C. Andrews professor of obstetrics and gynecology.

Dr Abuhamad's innovation and creativity have resulted in 3 patents (system, method, and medium for acquiring and generating standardized operator-independent ultrasound images of fetal, neonatal, and adult organs; a cerclage suture removal device; and a compression balloon belt for postpartum hemorrhage). This same vision for improving diagnosis and treatment of pregnant women has resulted in 160+ abstracts, which is just a small reflection of his tireless research efforts and his commitment to educating his fellow clinicians and ensuring superb-quality health care.

Currently associate editor in obstetrics for the *Journal of Ultrasound in Medicine*, Dr Abuhamad has served on the editorial boards of 3 other journals and is a reviewer for 11 other prestigious medical journals from the *New England Journal of Medicine* to *Lancet*. A prolific author, he has 5 books to his name (including *Ultrasound in Obstetrics and Gynecology: A Practical Approach*,

an e-book with free open access), 31 book chapters, and more than 156 articles in peer-reviewed journals. Dr Abuhamad is also the recipient of a National Institutes of Health (NIH) R01 grant award for the application of novel ultrasound techniques in the study of the human placenta in early gestations—part of the NIH Human Placenta Project.

Because of his desire to promote the proper use of ultrasound not only within his specialty but among all clinicians, Dr Abuhamad was instrumental in the establishment of 2013 as the Year of Ultrasound. It was under his leadership as AIUM president that the Ultrasound First initiative began, which included an Ultrasound First Forum that addressed the expanding role of ultrasound imaging as a “first” imaging examination, as well as the creation of an ongoing series of Sound Judgment clinical vignettes in the *Journal of Ultrasound in Medicine*. Active in many professional societies, Dr Abuhamad has also served as president of the Maternal-Fetal Medicine Foundation and the Society of Ultrasound in Medical Education.

It is not surprising that a physician of the caliber of Dr Abuhamad has earned numerous awards, ranging from a National Faculty Award for Excellence in Resident Teaching to a Presidential Recognition Award to a Dean's Outstanding Faculty Award. But, he has also been recognized 8 separate times as one of the Best Doctors in America; *Hampton Roads Magazine* has named him a Top Doctor every year since 2003; and he has twice received the Healthcare Hero's Award. A hero to many of his patients, Dr Abuhamad is selfless in his concern for others. Through the International Society of Ultrasound in Obstetrics and Gynecology, for which he chairs the Outreach Committee, Dr Abuhamad has engaged in 7 outreach humanitarian trips to Haiti, Ghana, and Somaliland.

Yes, Dr Abuhamad is a skilled physician, a consummate educator, an ingenious inventor, a humble humanitarian—and, indeed, a true clinical pioneer.

# 2016 AIUM Award Winners

## Peter H. Arger Excellence in Medical Student Education Award

---

*The Peter H. Arger, MD, Excellence in Medical Student Education Award was established in 2013, with its first presentation occurring at the 2014 AIUM Annual Convention in Las Vegas, Nevada. Dr Arger has contributed much to the AIUM and to the growth of diagnostic ultrasound, but his true passion has been ultrasound education. This annual presentation honors an individual whose outstanding contributions to the development of medical ultrasound education warrant special merit.*

## John Christian Fox, MD, RDMS, FACEP, FAAEM, FAIUM



John Christian Fox, MD, RDMS, FACEP, FAAEM, FAIUM, has done a lot of traveling in his educational journey. Born on the East Coast, he earned his bachelor's degree on the West Coast at the University of California (UC), Irvine, and then traveled back across the continent to obtain his medical degree at Tufts University. He returned to the West Coast to complete his residency in emergency medicine but then tarried in the Midwest for his fellowship at the University of Illinois, Chicago, before completing his journey back on the West Coast at the

UC Irvine Medical Center, where he is professor of clinical emergency medicine, vice chair of academic affairs, emergency ultrasound fellowship director, and assistant dean of student affairs. Not one to let moss grow under his feet, Dr Fox is also an adjunct professor at the University of New England, Armidale, Australia, as well as at the University of Santo Tomas, Manila, Philippines.

Dr Fox's passion for ultrasound education has had, and will continue to have for the foreseeable future, a profound impact on medical students, practicing clinicians (especially emergency medicine specialists), and, ultimately, patients, who are receiving better, more comprehensive, and less expensive care. During the past 15 years, Dr Fox has received \$1.6 million in grants for ultrasound instruction with an emphasis on medical students, international ultrasound teaching, a curriculum for bedside ultrasound training, and faculty development—all of which will have many long-term benefits.

With his commitment to medical education, it is not surprising that Dr Fox has written 66 peer-reviewed articles, close to 3 dozen books chapters, and 3 exceptional textbooks, but he has also created 10 multimedia (DVD) publications, been invited to give 40+ presentations at educational institutions, been a guest speaker 200 times in 37 different states, and lectured another 200 times at professional meetings, not to mention the abstracts he has presented or the lectures he has given to medical students at the UC Irvine School of Medicine.

But it is not the number of papers or professional appearances that is important, it is the subject matter, the quality of the presentations, and the superior hands-on instruction from physics and knobology to cost-effective imaging and critical decision making that resonates. His teaching skill is reflected in the 2 dozen honors and awards he has received for Medical Student Faculty Teaching, Emergency Ultrasound Teaching, Academic Excellence, Outstanding Faculty Service, Excellence in Teaching, and Emergency Ultrasound Educator of the Year, just to name a few. And let us not forget his exceptional TEDxUCIrvine presentation "Point of Care Revolution: Ultrasound" in 2015.

One would not think that Dr Fox would have time for much else, but like many emergency physicians, he thrives under pressure and handles multitasking with ease. For the AIUM alone, he has served on the Finance Committee, Web Development Committee (vice chair), Clinical Standards Committee, Membership Committee, Clinical Content Task Force, Annual Convention Committee, and Emergency Section (cochair), but he is also an active member of 9 societies, having served in various roles from cochair of the Ultrasound Multimedia Task Force of the Society of Critical Care Medicine to panelist for the Early First-Trimester Sonography Guideline Consensus Panel of the Society of Radiologists in Ultrasound. In addition to his membership on numerous committees for UC Irvine, Dr Fox served for 10 years as faculty advisor for the Flying Samaritans UCI, supervising undergraduate students, medical students, and postgraduate residents at a free medical clinic in El Testerazo, Baja California; since 1989, Dr Fox has made 115 trips!

Dr Peter H. Arger is known for his intense concern for patients, his powerful commitment to medical teaching, and his strong belief in outstanding ultrasound education, and Dr Fox mirrors those values and traits, which makes him the ideal recipient of this award.



# 2016 AIUM Award Winners

## Distinguished Sonographer Award

---

*Established in 1997, the Distinguished Sonographer Award is a means of recognizing and honoring current or retired AIUM members who have significantly contributed to the growth and development of medical ultrasound. This annual presentation honors an individual whose outstanding contributions to the development of medical ultrasound warrant special merit.*

### Daniel A. Merton, BS, RDMS, FSDMS, FAIUM



If individuals thinking about careers in sonography wondered what heights they could achieve, they would need look no further than the curriculum vitae of Daniel A. Merton, BS, RDMS, FSDMS, FAIUM. Currently a senior project officer for the Health Devices Group at ECRI Institute in Pennsylvania, Mr. Merton learned that ultrasound was used for diagnostic medical applications during his service in the US Navy when he served as a sonar technician. After receiving an associate degree in biology/zoology (with honors) at the State

University of New York, he transferred to Thomas Jefferson University where he earned his bachelor of science degree in diagnostic imaging (cum laude) in 1988, and that was the start of his meteoric rise.

After graduating, he became a staff sonographer at Thomas Jefferson University Hospital, and 3 years later, became a research sonographer. In 1993, Mr. Merton was hired as the technical coordinator of research for the Jefferson Ultrasound Research and Education Institute (JUREI). His attention to detail, in-depth knowledge of ultrasound, excellent writing skills, and commitment to research made him the ideal professional for this position. Many sonographers are asked to be part of a research grant or two, but few have been involved in more than 30 grant-funded activities as has Mr. Merton, including support from the National Institutes of Health, the US Agency for International Development, and numerous pharmaceutical and medical device companies.

Coauthor of the book *An Atlas of Ultrasound Color Flow Imaging* with Barry Goldberg, MD, Mr Merton has also penned 20 book chapters. In addition, he has authored or co-authored more than 100 articles in peer-reviewed journals—a claim to fame that not many clinicians or ultrasound researchers have achieved—as well as another 80 articles online and in trade magazines. It is, therefore, not surprising that he has received the Kenneth R. Gottesfeld Award from the Society of Diagnostic Medical Sonography (SDMS) 3 times; this award recognizes sonographer authors for the publication of outstanding research. Throughout his career, Mr Merton has regularly been rec-

ognized for his achievements ranging from an Alumni Special Achievement Award from the Jefferson College of Health Professions, to a Presidential Recognition Award from the AIUM, to a Telly Award for “Ultrasound: New Advancements,” and recognition from CIVCO, DuPont Pharmaceuticals, and Medison—just to name a few of his honors.

Both sonographers and sonologists have benefited from his high-level of expertise and superb teaching skills, as Mr Merton has been invited to lecture at nearly 200 local, national, and international imaging society meetings. Mr. Merton has provided many lectures as a clinical instructor for JUREI and has presented more than 200 scientific abstracts. Moreover, he has been a coauthor on 55 scientific posters and exhibits, many of which have received first-, second-, and third-place honors, certificates of merit, and honorable mentions.

He’s a writer, a researcher, an educator, and a sonographer (oh, and a husband and father of 2 boys), so it’s hard to imagine that Dan would have time for anything else. However, he cares deeply about promoting exceptional ultrasound practice and ensuring that all sonographers have the requisite skills to ensure superb patient care through education and credentialing. Thus, he has been an active member of the SDMS, the American Registry for Diagnostic Medical Sonography (ARDMS), and the AIUM, serving on countless committees and task forces, as well as the editorial board of both the AIUM’s and the SDMS’s journals, and the board of governors for both the AIUM and the ARDMS. He is the current treasurer of Inteleos—the parent organization of the ARDMS. “Distinguished Sonographer” is an understatement when it comes to Mr Merton.

# 2016 AIUM Award Winners

## Honorary Fellow Award

---

*The Honorary Fellow Award bestows an honorary membership to individuals who have contributed significantly to the field of ultrasound.*

### Aris T. Papageorghiou, MD, FRCOG



Aris T. Papageorghiou, MD, FRCOG, is professor in fetal medicine and obstetrics at St George's Healthcare NHS Trust in London and associate professor of fetal medicine at the Nuffield Department of Obstetrics and Gynaecology, University of Oxford. He earned his medical degree at the University of Sheffield and completed his doctoral thesis at the University of London—while he was a research fellow at the Harris Birthright Research Centre for Fetal Medicine—on the prediction of preeclampsia using uterine artery Doppler ultrasound (the

largest study on this topic to date).

Dr Papageorghiou subsequently completed specialist training in obstetrics and gynecology and subspecialist training in maternal-fetal medicine while serving as a lecturer at St George's, University of London. An internationally recognized expert in fetal diagnosis and therapy, Dr Papageorghiou has also developed a keen interest in medical statistics, which has served him well in his work on large population-based studies (eg, the characterization of normal and abnormal fetal and neonatal growth in relation to maternal and fetal nutritional status) and international multicenter research endeavors (eg, INTERGROWTH-21st and INTERBIO-21st). He is engaged in active research collaborations with Liverpool University, Cambridge University, University of London, University of Oxford, and the Shoklo Malaria Research Unit in Thailand and is beginning work on a proposed project on the introduction of fetal growth standards and tools for phenotypic characterization.

Committed to education and having a love of teaching, he has trained sonologists across the globe, served as an advisor to 6 postgraduate students, teaches in the MBBS program at St George's, and been a trainer and examiner for the MRCOG (membership examination of the Royal College of Obstetricians and Gynaecologists). In addition to authoring several book chapters and serving as coeditor of a major textbook on obstetrics and gynecology and coauthor of *Obstetric Ultrasound: A Problem-Based Approach*, Dr Papageorghiou has penned close to 200 journal articles.

Fluent in English, Greek, and German, with good knowledge of Spanish, it is not surprising that Dr Papageorghiou has a passion for providing ultrasound to underserved communities worldwide. As part of his fetal growth studies, he has shown that it is possible to train local workers with little health training to obtain accurate fetal measurements using ultrasound, which has the potential to reduce maternal and perinatal mortality and morbidity.

An avid reader and amateur photographer with interests in contemporary art, modernist architecture, and scuba diving, Dr Papageorghiou—with his dedication to research, teaching, and global ultrasound—has set the bar high for other physicians. The AIUM is delighted to welcome him to the organization as an honorary fellow.

# 2016 AIUM Award Winners

## Honorary Fellow Award

---

*The Honorary Fellow Award bestows an honorary membership to individuals who have contributed significantly to the field of ultrasound.*

### Paul Sidhu, BSc, MBBS, MRCP, FRCR



Paul Sidhu, BSc, MBBS, MRCP, FRCR, is the fifth individual from King's College London to be designated as an AIUM honorary fellow. This says volumes about the ultrasound expertise associated with King's, as well as being a reflection of the exemplary skills and proficiency that Dr Sidhu brings to the world of medical ultrasound. Currently professor of imaging sciences and consultant radiologist at King's College London, Dr Sidhu has excelled in both academia and athletics since his undergraduate days—not necessarily a common combination

among physicians. His list of postgraduate awards and prizes consumes 4 single-spaced pages printed in a font size that would be an optician's dream. They include a magnum cum laude and a cum laude scientific exhibition award from the European Association of Radiologists, as well as a cum laude award and 4 certificates of merit for his poster presentations for the Radiological Society of North America.

Dr Sidhu is the author of more than 200 peer-reviewed papers, 52 book chapters, and 5 books. Authors that prolific rarely have time to do little else, but Dr Sidhu has served as past president of the British Medical Ultrasound Society and of the Section of Radiology of the Royal Society of Medicine and is currently the president-elect of the European Federation of Societies for Ultrasound in Medicine and Biology. In addition, he is an active member of 13 professional radiology associations, serving for many in the capacity of committee chair or member, as well as officer—just a small indication of his commitment to staying current in all aspects of his field with the goal of providing superlative patient care.

Currently editor of the *European Journal of Ultrasound (Ultraschall in der Medizin)*, Dr Sidhu is a past deputy editor of the *British Journal of Radiology*, has been a member of the editorial boards of 10 medical journals, and has served as guest editor for 2 imaging journals. It should come as no surprise that he received an Editor's Recognition Award 5 years in a row from *Radiology* for his high-quality, prompt, detailed, and scholarly reviews.

Dr Sidhu will humbly claim to have given approximately 300 lectures, but if you study his curriculum vitae, you will see that the number of invited workshops, lectures, and presentations is nearing the 600 mark, and these include talks presented throughout Europe and North America, as well as in Australia, Asia, the Middle East, and Egypt.

Recognized as a world authority on the application of contrast-enhanced ultrasound in clinical practice, Dr Sidhu is an expert in male health, liver transplantation, and vascular interventional radiology. Through all his work—publishing, lecturing, and clinical practice—he has continually demonstrated his dedication to the highest quality medical standards. His patients, his colleagues, his readers, and his attendees receive only the best. Dr Sidhu is the quintessential ultrasound professional. The AIUM is proud to have him as an honorary fellow.



# 2016 AIUM Award Winners

## Memorial Recognition

---

*Established in 2002, Memorial Recognition serves as a posthumous tribute to a creative and devoted physician, research scientist, or other member who has contributed to the field of ultrasound in medicine. The honoree is recognized at the Opening Session during the AIUM Annual Convention.*

### Anna S. Lev-Toaff, MD, FAIUM, FACR, FSRU



It was with great sadness that the AIUM learned of the too-early death of Anna S. Lev-Toaff, MD, FAIUM, FACR, on April 3, 2015, at only 60 years of age due to complications secondary to multiple myeloma. This distinguished clinician and respected researcher received her bachelor's degree in biology and her medical degree from New York University. She subsequently trained in surgery at Pennsylvania Hospital in Philadelphia and Tel Aviv University in Israel before completing her radiology residency at the Thomas Jefferson University

Hospital in Philadelphia, followed by an abdominal imaging fellowship at the Hospital of the University of Pennsylvania.

From 1985–1986, Dr Lev-Toaff was a radiology instructor at the Perelman School of Medicine at the University of Pennsylvania, an institution she would return to in 2008 as a professor of radiology and a member of the Clinical Practices of the University of Pennsylvania and where she would teach and practice until 2014. In between her stints at the University of Pennsylvania, she served on the faculty at Temple University from 1986–1990 and for 18 years at Thomas Jefferson University.

Coeditor of the textbook *Clinical Pelvic Imaging: CT, Ultrasound and MRI*, Dr Lev-Toaff's research interests centered around ultrasound contrast agents, 3-dimensional ultrasound, and virtual colonoscopy. This accomplished radiologist and academic focused her considerable clinical expertise on interventional ultrasound (ultrasound-guided biopsy), sonohysterography, virtual colonoscopy, abdominal/pelvic computed tomography and diagnostic ultrasound, 3-dimensional ultrasound, and gastrointestinal radiology. Her death is a loss to so many patients—people whom she cared about deeply.

A prolific author, Dr Lev-Toaff published 75 journal papers and more than 100 abstracts. Because of the respect for her knowledge and expertise, she was invited to present 200 lectures; her sharp wit and brilliant verbal skills made her the consummate educator. Generous to a fault, Dr Lev-Toaff was known by radiologists worldwide for her concern for those in need and her commitment to her profession and to her patients. Due to her many accomplishments in research,

education, and clinical and volunteer work, she was elected to fellow status by the AIUM, the American College of Radiology, and the Society of Radiologists in Ultrasound and was actively involved in all 3 organizations. A reflection of Dr Lev-Toaff's dedication to education and research, she served on the Editorial Board of the *Journal of Ultrasound in Medicine* and had been a member of the AIUM's Annual Convention Committee and its Endowment for Education and Research Committee.

We grieve with Dr Lev-Toaff's 4 children (her proudest accomplishment), her extended family, her colleagues worldwide, and her past and would-have-been patients; the world of radiology has lost one its best.

# 2016 AIUM Award Winners

## Memorial Recognition

---

*Established in 2002, Memorial Recognition serves as a posthumous tribute to a creative and devoted physician, research scientist, or other member who has contributed to the field of ultrasound in medicine. The honoree is recognized at the Opening Session during the AIUM Annual Convention.*

### Carol Mittelstaedt, MD, FAIUM



On March 12, 2015, Carol Mittelstaedt, MD, FAIUM, died at an age (69 years) when she was just beginning to enjoy her well-deserved retirement. A native of Arkansas, she earned a bachelor of science degree from the University of Arkansas in Fayetteville and her medical degree at the University of Arkansas Medical School. She subsequently completed a radiology residency at the same institution, followed by a fellowship in diagnostic ultrasound at the University of California San Diego under George R. Leopold, MD, FAIUM, editor emeritus of

the *Journal of Ultrasound in Medicine*.

She set high standards for those with whom she worked but provided the necessary support to her sonographers, residents, fellows, and colleagues to enable all to meet those standards. A superb cook and generous to a fault, Dr Mittelstaedt will be missed by her extended family, her AIUM and SRU colleagues, the many ultrasound professionals whose careers she guided, as well as those who never had the chance to meet her but who had the advantage to study her two widely acclaimed textbooks, *Abdominal Ultrasound* and *General Ultrasound*. The world has lost an exceptional medical professional.

Affectionately known as Dr Mitt, she was an ultrasound pioneer who founded the Clinical Ultrasound Service at the University of North Carolina (UNC) and was one of the first women appointed to the faculty of the Department of Radiology, where she served as director of ultrasound until 2004. Recognizing that the usefulness of medical ultrasound is dependent on the skill and knowledge of the person scanning, she founded a school of sonography at UNC.

A member of the AIUM for more than 3 decades, Dr Mittelstaedt was awarded fellowship status in 1990. As she did with everything, she gave the organization her all. She was a member of the AIUM's Board of Governors (1995–1998), chaired the Program Committee as well as what was previously known as the Abdominal Section, and served on the Annual Convention Committee, the Education and Research Scientific Advisory Committee, and the Americas Conference on Ultrasound Committee. She was also active in the Society of Radiologists in Ultrasound (SRU), serving as program chair and chair of the SRU's Constitution Committee. In addition, she examined in ultrasound for the American Board of Radiology in the late 1980s.

An exceptional teacher, she was an invited lecturer at national and local radiology conventions and at foreign medical convocations in Chile, Egypt, Hong Kong, and Thailand. An ideal mentor, she nurtured the careers of many who would go on to become leaders in medical ultrasound. Indeed, it was due to her efforts in introducing young faculty to ultrasound that inspired many to choose ultrasound as their main specialty of interest. She was ahead of her time in recognizing the importance and value of diagnostic ultrasound.

# Endowment for Education and Research Donors



Endowment for Education and Research

*The AIUM's Endowment for Education and Research (EER) was created to provide much-needed funding for ultrasound research and educational initiatives. What makes this possible is the generous support of AIUM members, vendors, and individuals who provide gifts in honor or in memory of ultrasound professionals.*

*It is with great appreciation that the AIUM thanks the individuals listed below who contributed to the EER during the 2015 campaign. These individuals have a ribbon on their name badge acknowledging their generosity; please thank them for their support. If you would like to make an EER donation, you can do so at the Registration Desk.*

## Contributions of \$1000 and Above

Alfred Abuhamad, MD, FAIUM  
 Peter Arger, MD, FAIUM, FACR  
 David Bahner, MD, RDMS, FAIUM, FAAEM, FACEP  
 Beryl Benacerraf, MD, FAIUM  
 Bryann Bromley, MD, FAIUM  
 Brian Coley, MD, FAIUM  
 Joshua Copel, MD, FAIUM  
 Jude Crino, MD, FAIUM  
 Arthur C. Fleischer, MD, FAIUM  
 Leonard Glassman, MD, FAIUM, FACR  
 Barry Goldberg, MD, FAIUM  
 Steven Goldstein, MD, FAIUM  
 Lennard Greenbaum, MD, FAIUM  
 Luis Izquierdo, MD, MBA, CPE, FAIUM  
 Luleta Maslak, RDMS  
 Samuel Maslak, DSc, FAIUM  
 Levon Nazarian, MD, FAIUM, FACR  
 Harvey L. Nisenbaum, MD, FACR, FAIUM, FSRU  
 Kevin Parker, PhD, FAIUM  
 Kathryn Reed, MD, FAIUM  
 Thomas Shipp, MD, RDMS, FAIUM  
 James Shwayder, MD, JD, FAIUM  
 Carmine Valente, PhD, CAE  
 Joseph Wax, MD, FAIUM

## Contributions of \$250 to \$999

Lisa Allen, BS, RDMS, RDCS, RVT, FAIUM  
 Rochelle Andreotti, MD, FAIUM  
 Carol Benson, MD, FAIUM  
 Peter Doubilet, MD, PhD, FAIUM  
 J. Brian Fowlkes, PhD, FAIUM  
 Phyllis Glanc, MDCM, BSC, FRCPC, FAIUM  
 H. Theodore Harcke Jr, MD, FAIUM  
 Glynis Harvey, CAE  
 Charlotte Henningsen, MS, RT, RDMS, RVT, FSDMS, FAIUM  
 Frederick Kremkau, PhD, FACR, FAIMBE, FAIUM, FASA  
 Alfred Kurtz, MD, FAIUM  
 David Paushter, MD, FAIUM  
 Gary Whitman, MD, FAIUM  
 Isabelle Wilkins, MD, FAIUM

## Contributions of \$36 to \$249

Anthony Ambrose, MD, FACOG  
 Erin Arnold, MD, FACR  
 Anthony Bacevice Jr, MD, MSE  
 Andrea Barry, MD  
 Victoria Belogolovkin, MD  
 Teresa Bieker, MBA, RT, RDMS, RVT, RDCS, FAIUM  
 David Blews, MD  
 Deborah Brown, BA, RDMS, RDCS  
 Douglas Brown, MD, FAIUM  
 Elizabeth Brown, RDMS  
 Wui Chong, MD, FRCR, FAIUM  
 William Clewell, MD  
 Harris L. Cohen, MD, FACR, FAIUM, FSRU  
 Maricela Contreras, MD  
 Marianne Cullen, BS  
 Andrea Curtis, RDMS, RVT  
 Eugene Danko, MD  
 Mary Davey, MD  
 John Donlon  
 Hostos Fernandez-Caamano, MD  
 Flemming Forsberg, PhD, FAIUM, FAIMBE  
 Anne Freitas, MD  
 Karen Fung Kee Fung, MD, FRCSC, MHPE  
 Jing Gao, MD, FAIUM  
 Edwin Goldstein, MD, FACR  
 Sheryl Goss, MS, RT, RDMS, RDCS, RVT, FSDMS  
 Diana Gray, MD, FAIUM  
 John Gullett, MD  
 Marc Hirsh, MD, FACP  
 Christy Holland, PhD, FAIUM  
 Mark Holland, PhD, FAIUM  
 Calvin Huang, MD, MPH  
 Jon Jacobson, MD, FAIUM  
 Mohamad Jbeily, MD  
 Nancy Judge, MD  
 Diane Kawamura, PhD, RT(R), RDMS, FAIUM, FSDMS  
 Brian Keroack, MD

Holly Kodner, MD  
 Kenneth Lee, MD  
 Kenneth Lee, PhD  
 Sarah Lee, MD, FACOG  
 Seth Lotterman, MD  
 David Luthy, MD  
 Felix Martin  
 Raymond Marty, MD  
 T. Douglas Mast, PhD  
 Shoichi Matsutani, MD  
 Alexander Mentakis, MD  
 Donna Neale, MD  
 Lewis Nelson III, MD, FAIUM  
 Marsha Neumyer, BS, RVT, FSVU, FAIUM, FSDMS  
 John Nitsche, MD  
 Francis Nuthalapaty, MD  
 Zanet Oschman, MBChB, MSc, RDMS  
 Jennifer Pearson, RDMS, RVT, RTR  
 Barbara Pittenger, RDMS  
 Michael Potruch, MD  
 Luis Ortiz Quintana, MD, PhD  
 Michelle Robbin, MD, MS, FACR, FSRU, FAIUM  
 Todd Rosen, MD  
 Julie Savinon  
 Jessica Silliman, RDMS  
 Ilan Timor-Tritsch, MD, FAIUM  
 Lan Tran, MD  
 Heidi Umphrey, MD, MS  
 Carmine Valente, PhD, CAE  
 Danilda Veloz, RDMS  
 Hassan Wehbeh, MD  
 Amy Whitley, MD  
 Fletcher Wilson, MD  
 Robert Wolfson, MD, PhD, FACOG, FAIUM  
 Jade Wong-You-Cheong, MD, RVT, FRCR  
 Cheryl Wyskiel, RDMS, RCMS  
 Brita Zaia, MD  
 Marvin Ziskin, MD, FAIUM



**Contributions up to \$35**

Michael Abdul-Malak, MD  
 Alyssa Abo, MD  
 Keith Abrahamson, BS, RDMS, RDCS  
 Anna Abramova, BS, RVT  
 Amjad Abuseni, RDMS  
 Nurdan Acar  
 El-Zein Adam Jr, MBBS, MSC, PhD  
 Deborah Adams, RDMS  
 Shelley Adams, MD  
 Tracy Adams, DO  
 Joseph Adashek, MD  
 Beni Adeniji, MD  
 Arun Adhate, BS, MPA, RDMS  
 Seetal Adhikari, MD  
 Srikar Adhikari, MD, MS  
 Nina Agres, RDMS  
 Zafar Ahmed Sr  
 Robert Ahrens Jr, MD  
 Anthony Akamaguna, MB, BS, DMRD  
 Vito Alamia Jr, MD  
 John Alcini Jr, MD  
 Kristin Algoe, MD  
 Clifford Allen II, DPM  
 Gregory Allen, MD  
 Vera Allison, RDMS, RVT, RDCS, RT  
 Karen Alton, BS, RT, RDMS, RVT  
 Muna Alzahrani, MS, RDMS, RVT  
 Azzdine Ammi  
 Cynthia Anderson, MD, MPH, FACOG  
 Libby Anderson, MD  
 Sara Anderson, MD  
 Tammy Anderson, RDMS  
 Michael Andre, PhD, FAIUM, DABR  
 Lydia Appiah-Dwamena, MD  
 Jackie Appleby, MS  
 Hisham Arab, MD  
 Edward Araujo Junior, PhD  
 Shawn Arendall, RDMS  
 Yasuyuki Asakawa, MD, PhD  
 Adam Ash, DO, RDMS  
 Graham Ashmead, MD, FACOG  
 Mohamed Ashour, MD  
 Tamerou Asrat, MD, FACOG  
 Janet Aube, RDMS  
 Stephen Avery, MD  
 Jean Ayoub, MD, PhD  
 Chelsie Ayre, RT, RDMS  
 Nami Azar, MD  
 Kazunori Baba, MD, PhD  
 Ray Babb Jr, MD  
 Cristel Baiu, MS  
 Diana Baker, MD  
 Stewart Bakst, MD  
 Kanu Bala, MBBS, PhD, FRCP, FAIUM  
 Juanito Baladad, MD  
 Viren Balsara, MD

J. Oscar Barahona, BS, RDMS  
 Hannah Barrese, RDMS, RVT  
 Edgar Barros, RDMS  
 Joan Bartello  
 James Bartelsmeyer, MD  
 Bonnie Bartley, RDMS, RDCS  
 Ahmet Baschat, MD  
 Naz Basit, MBBS, RDMS  
 Harold Bass, MD  
 Adrien Bastide Sr, MD  
 Marcus Bastos, MD, PhD  
 Laurel Bauer, MD  
 Nicki Bauer, RDMS, RDCS, RVT, RT  
 Jim Baun, BS, RDMS, RVT, FSDMS  
 Matthias Beck, MD, PhD  
 Brent Becker, MD  
 Karen Beckerman, MD  
 Theodore Bedard, MD  
 Michael Beecher, MB, BS, DM, FACOG  
 Rob Beekmans  
 Lindsey Behan, MD  
 Gwendolynn Belle, RDMS  
 Shaibu Bello, BSc, MB, ChB, PhD  
 Nasrin Benion, RDMS  
 Louise Bennett, RTR, RDMS, RVT  
 Tara Bennett, MD  
 Ira Berger, MD  
 Randy Berke, MD  
 Apolonio Bernardo, MD, FPCR  
 Vidor Bernstien, MD  
 Anne Berube, MD, FRCP(C)  
 Indra Besasar  
 Pamela Besse, RT, RDMS  
 Kenneth Bielak, MD  
 Felix Bigay, MD  
 Angela Biggs, MD  
 Christine Bird, BS, RDMS, RVT  
 Kimberly Biss, MD  
 Nadine Bjorklund, RDMS, RT(R)(M)  
 Marlene Blair, RT(R), RDMS  
 Richard Blair, MD  
 Barbara Blankenship, MD  
 Josef Blankstein, MD  
 Donna Blodgett, RDMS  
 Yair Blumenfeld, MD  
 Amy Blumenthal, MD, FACOG  
 Paul Bobby, MD  
 Kris Bodnar, MD  
 Jean Bolan, MD  
 Annette Bond, MD  
 Frank Bonelli, MD, PhD  
 Linda Boon, MD  
 Donald Boos Jr, MD  
 Edgar Booth, MD  
 Michael Bork, DO  
 Gary Boss, RDMS, RDCS  
 Sandra Bowdoin, BS, RDMS, RDCS, RVT, RMSK  
 Brian Bower, MD  
 Elizabeth Bowman, RDMS, RT(R)

Roxie Bozicevich, MD  
 Kathleen Bradley, MD  
 Harbinder Brar, MD, FACOG, FACS, FACMG  
 Karla Brehmer, RDMS RVT  
 Lesley Brennan, RDMS  
 Steven Brenner, MD  
 William Brewer, MD  
 Laurie Briare, RT, RDMS, RVT  
 Marla Bridgford, BS, RDCS, RDMS  
 Justin Briones, MD  
 Monica Brito, MD, FACOG, RDMS  
 Steven Broadstone, PhD  
 Marsha Brody, RDMS  
 Fredrik Broekhuizen, MD  
 George Bronsky, MD  
 Debra Brooks, BS, RTRM, RDMS, RVT  
 Bart Brown, MD  
 Brenda Brown, RDCS, RDMS  
 Jacqueline Brown, MD, FRCPC  
 Michele Brown, MD  
 Carol Brown-Elliott, MD  
 Hermann Bruhwiler, MD  
 Ruth Brush, MD  
 Richard Budenz, MD, PhD  
 Syed Bukhari, MD  
 Susan Bunch, MD  
 Nathalie Bureau, MD, MSc, FRCP(C)  
 M. Shannon Burke, MD  
 Leigh Burrell, RT, RDMS  
 Felecia Burrow, BS, RT, RDMS, RVT  
 Michelle Bursese, RDMS  
 Anzhelina Burukina  
 Jacqueline Bush, MD  
 Raydeen Busse, MD, FACOG  
 Dominique Butawan-Ali, MD  
 Jeffrey Butler, DO, RDMS  
 Michael Cabbad, MD  
 Alan Cadkin, MD  
 Peter Callen, MD, FAIUM  
 Charles Camacho, MD  
 Clare Cammarano, MD  
 Angelo Campagna, MD, FRCS(C), FACOG  
 Kevin Campbell, MD  
 Glaciliane Canario  
 Patricia Cantu, BS, RT(R), RDMS, RVT, RDCS  
 Susan Capelle, MD  
 Etienne Cardinal, MD  
 Reynaldo Cardoso-Medinilla, MD, FRCS(C)  
 Eric Carlson, DO, MPH  
 Karen Carlson, RDMS, RVT  
 Francis Carmody, MBBS, FRCOG, FRANZCOG, DDU  
 Robert Carpenter Jr, MD, JD  
 Margaret Carr, MD  
 Jorge Carrascosa  
 Graciela Carrera, RDMS  
 Patricia Carroll, RDMS

Anthony Carter, MD  
 Margaret Carter, MD  
 Mark Cartier, BS, RDMS, RT  
 Vincent Caruso, RVT, RDMS  
 Elba Cases, BS, RDMS, RDCS  
 Doty Casey  
 Michael Cavanaugh, MD  
 Eugenio Cerezo, MD  
 Diane Cervantez, RDMS, BSU, MHM  
 Sarah Chambers, MD  
 Linda Chambliss, MD, MPH  
 Ka Fai Chan, BS, RDMS, RDCS  
 Rubila Chaudhry  
 Devjani Chaudhuri, MBBS, DMRD, MD, RDMS  
 Meera Chaudhuri, MD, FACOG, FRCOG  
 Emiliano Chavira, MD, MPH  
 Bruce Chen, MD  
 Miranda Cheung  
 Mary Chiavaras, MD, PhD, FRCPC  
 Rabeya Chowdhury, MD  
 Cara Chudewicz, MD  
 Charles Church, PhD, FAIUM  
 Carol Chytka, RDMS, RVT, BS, RT(R)  
 Antonio Ciccotelli, MD  
 Betty Ann Cirillo, MD  
 Marc Clachko, MD  
 William Clark, MD  
 Daniel Clement, MD  
 Marianne Clements, RDMS  
 Philip Clements, MD  
 Taneille Clouden, RDMS, RDCS  
 H. Gene Cohen, MD  
 William Cohen, MD  
 Beverly Coleman, MD, FACR, FAIUM  
 Fred Coleman, MD  
 Justin Collingham, MD  
 Terry Collins, MD  
 Debra Colson, RT(R), RDMS, RVT, RVS  
 Nicole Coluccio, MD, FACOG  
 Edward Condon, MD, ECNU  
 Mary Connell, MD  
 Diana Connor, MD  
 Curtis Cook, MD  
 Jessica Cook, RDMS  
 Richard Cook, MD  
 Andrea Corda, MD  
 Laura Corio, MD  
 Maureen Cosentino, RDMS  
 Erich Cosmi, MD, PhD  
 Brian Couri, MD  
 Jacqueline Cox, RDMS, RT  
 Marisa Craddock  
 Michael Crade, MD  
 John Craig, MD  
 Joseph Craig, MB, ChB  
 William Craig IV, MD  
 Tonie Crandall, MD

Stephen Crane, MD  
 Tonya Crawford, RDMS  
 Krystine Crawley, RTR, RDMS  
 Eve Cunningham, MD  
 William Curtin, MD  
 Amos Cutler, MD  
 Diane Dalecki, PhD, FAIUM  
 A. Paul Dallas, MD, FACP, CHCP  
 Brien Daly, MD  
 Sara Damewood, MD  
 Sean Daneshmand, MD  
 Kassa Darge, MD, PhD  
 Raymon Darling, MD  
 Reza Daugherty, MD  
 Jaydev Dave, PhD, DABR, MS  
 Michael Davies, MA  
 Janet Davis, RDMS  
 Judy Ann Davis, RDMS  
 Leon Davis Jr, MD  
 Leslie Davis, MD, FACOG  
 Mark Davis, MD  
 Aida Davydova, RDMS, RDCS, RVT  
 L. Dorine Day, MD  
 Sue Ann Dayton, RDMS, RRT  
 Maria De Elejalde, MS, RN  
 M. Robert De Jong Jr, RDMS, RDCS, RVT, FSDMS, FAIUM  
 Rosa De Vermette, MD, RDCS, RDMS, ROUB  
 Robert Debbs, DO, FACOG  
 Gary DeGuzman, MD  
 Brian Delahoussaye, MD  
 Anton Delport, MD  
 Nicole DeLuca, MS, RDMS, RDCS, RVT  
 Patricia Delzell, MD  
 Paul DeMarco, MD, FACP, FACR, RhMSUS  
 Emily Demoss, RDMS, RVT  
 Diane Denis, RDMS  
 Eusebio Desuyo, MD, MBA, MPH, RDMS  
 Richard DeVeaux, MD, FACOG  
 Lawrence Devoe, MD  
 Gregory DeVore, MD, FACOG, FAIUM  
 David Dichiaro, MD  
 Jeffrey Dicke, MD  
 Kathleen DiGiulio, MS, RDMS, RVT, RDCS  
 Cristina Dinicu, MD  
 Michael Di Pietro, MD, FAIUM  
 Susan Ditmanson, MD  
 Michael Divon, MD  
 Susan Dodd, MD  
 Aleida Dominguez, RDMS  
 Steven Domnitz, MD  
 Leslie Donahue, RDMS  
 Jennifer Donofrio, MD  
 Bernice Doring, RT, RDMS  
 N. Carol Dornbluth, MD, MA  
 John Doss, MD, FACOG  
 Mark Downey, RT, RDMS, RVT

Thomas Downs, MD, FACOG  
 Nancy Dowsett, RDMS, RT  
 Marla Doyle, BSRT, RDMS  
 Michael Doyle, MD  
 Richard Dreiss, MD  
 Kathryn Drennan, MD  
 Lee Dresang, MD  
 Todd Drexel, DO, MPH  
 Dawn Driver, RDCS, RDMS, RVT  
 Elcio Duarte  
 Terry DuBose, MS, RDMS, FAIUM, FSDMS  
 Eva Duckett, MD  
 Christine Dudiak, MD  
 Donna Dunn, RDMS  
 James Dunphy, MD  
 Carolyn Dupuis, MD  
 Maria Duran, RDMS  
 Bernard Durante, MD  
 Gerald Dysert, MD  
 Mary Earle, BA, RDMS  
 Colette Eastman, DO  
 Katherine Eastwood, MD  
 Martin Ebenger, MD  
 Ian Ebesugawa, MD  
 Bryn Echevarria, RRT  
 Keith Eddleman, MD  
 Rick Edmiston  
 Christine Edwards, MD  
 Robert Edwards III, MD  
 William Edwards, MD  
 Victor Efughi, MSc  
 Robin Ehrenpreis, MD  
 Amy Eichfeld, MD  
 Michael Eisen, MD  
 Vita Eizans, DO  
 Duke Eldridge, MS  
 B. Rafael Elejalde, MD, AFACOG, FACMG, FAIUM  
 Eman El Gammal, MBBCH  
 Andrew Elimian, MD, FACOG  
 Susan Elmore, MHA, BS, RDMS  
 Sandra Emmons, MD  
 Jose Enriquez, MD  
 Nancy Eriksen, MD  
 Frederick Eruo Sr, MPH, MD  
 Sharon Eskam, MD  
 Carol Espejo, MD  
 Eduardo Espinosa, MD  
 Judy Estroff, MD  
 Elizabeth Etkin-Kramer, MD  
 Peter Evan, MUDR  
 John Evans, MD  
 Walter Evans II, MD  
 Wayne Evans, MD  
 Philippe Extermann, MD  
 Leonard Fagan, MD  
 Patricia Fagan, MD  
 Joseph Fakhry, MD, FAIUM  
 Darren Farley, MD  
 Shahid Farooqi, MD  
 Mark Favot, MD, RDMS, RDCS  
 Faiza Fayyaz, MBBS, RDMS

Khanum Fehmida, RDMS, RVT  
 Ding-Yu Fei, PhD  
 Damariz Feliz  
 John Feore, MD  
 Asaf Ferber, MD  
 Carlos Fernandez, MD  
 Stephanie Fernandez, RVT  
 Luis Fernandez-Sifre, MD  
 Lauren Ferrara, MD  
 Darla Ferrell, RDMS  
 Dan Fertel, MD, RDMS, RVT RPVI  
 Steven Fettingier, MD  
 Victoria Fewell, MD  
 Jacqueline Fielding, BS, RDMS  
 Reinaldo Figueroa, MD  
 Brent Finley, MD, MBA, RDMS  
 Joanne Finn, MD  
 Mark Finnegan, MD  
 Albert Fiorello, MD, RDMS, FAAEM, FACEP  
 Stuart Fischbein, MD  
 Matthew Flannigan, DO  
 Randall Floyd, MD  
 Katherine Foley, MD  
 Jon Foran, MD  
 Melissa Foreman, RDMS, RVT, FSDMS  
 Iraj Forouzan, MD  
 Jean Forrester, RDMS, RRT  
 Luis Forte, RDMS, RVT, RDCS  
 Stephen Fortunato, MD  
 Lisa Foster, RDMS  
 David Foulk, MD  
 Debra Fouts, RDMS, RDCS  
 Richard Foveaux, DC, MSci, DACBSP, CSCS  
 Karin Fox, MD  
 Nathan Fox, MD  
 Pamela Foy, MS, RDMS, FSDMS  
 Gerard Foye Jr, MD  
 Terrell Frain, RDMS  
 Jennifer Franz, RT, RDMS  
 Thomas Freenock Jr, MD  
 Atis Freimanis, MD, FAIUM  
 Maija Freimanis, MD  
 Meredith Fresquez, BSN, RDMS  
 Gene Freylikhman, MD  
 Karen Fried, MD  
 Franklin Friedman, MD  
 Esther Friedrich, MD  
 Emma Fritz, MD, MPH  
 Doug Frye, MD  
 Tomasz Fuchs, MD  
 Armando Fuentes, MD, MBA  
 Pat Fulgham, MD  
 George Fyffe, MD  
 Donald Fylstra, MD  
 Michael Gabriele, MD  
 Carol Gagliardi, MD  
 Robert Gagnon, MD, FRCS, RDMS  
 Maureen Galang, RDMS, RDCS, RVT  
 Michael Gallagher, MD

Shital Gandhi, MBBS  
 Vijaya Ganesh, MD  
 Bryan Ganter, MD  
 Dian Gantt, CRNA  
 Elizabeth Garduno, MD, MPH, FACOG  
 Brian Garra, MD, FAIUM  
 David Garry, DO  
 Romolo Gaspari, MSc, MD, PhD, FACEP  
 Valary Gass, MD  
 Frank Gaudier Jr, MD  
 Charles Gbadouwey, MD, FACP, FCCP  
 George Gentchos, MD  
 Pares Ghodge, MD  
 James Gibson, MD  
 John Gibson, MD  
 William Gilbert, MD  
 Martin Gimovsky, MD, FACOG  
 Guillaume Giraud  
 J. Christopher Glantz, MD, MPH  
 Irwin Glassman, MD  
 John Goble  
 Stephen Gocke, MD  
 Alfredo Goddi  
 Chris Goesser, DC, MD  
 Kara Goglia, MD  
 Cysandra Goins, RDMS, BS, RRT(S)  
 James Goldberg, MD  
 Shaindy Goldstein, RDMS  
 John Gomes, MD  
 Mark Gonzales, DO, MPH  
 Carlos Gonzalez, MD  
 Eduardo Gonzalez-Jove, MD  
 Mario Gonzalez Quiroz  
 Antonio Gonzalez-Ruiz, MD  
 Rob Goodman, MB, BChir  
 Sameer Gopalani, MD  
 Joseph Gordon, MD, FACS  
 Alan Gorrell, MD, RDMS, FACOG  
 Kiyotoshi Gotoh, MD, PhD  
 Evangelos Govas  
 Rosemarie Gower, RDMS  
 Vanessa Grano, MD  
 Andrew Gray, MD, PhD  
 Bronwyn Gray  
 Mary Grayson, RDMS  
 Donn Greaves, MD  
 James Green, MD  
 Michael Green, MD, FRCS  
 Richard Green, MD, BS  
 William Green, MD  
 William Greenhut, BA, RDMS  
 Laura Greer, MD  
 Jill Ann Shu Gregg, RDMS  
 Cliff Gronseth, MD  
 Kirby Gross, MD, FACS  
 Yvette Groszmann, MD, MPH  
 Jeotsna Grover, MD, FACOG  
 Brendan Grubbs, MD  
 Norma Grundset, RDMS, RVT  
 Danielle Grunsfeld, RDMS

Raphael Guichard, MD	Amy High, MD	Alexander Jung, MD	Jeffrey Korotkin, MD, MBA
Ravindu Gunatilake, MD	Joseph Hill, MD	Margarita Jurak, MD	Edward Korsberg, RDMS
Renee Gunter, RDMS	Randall Hill, MD	Ronny Kafiluddi, MD, PhD, FIPP, DABIPP	Karen Koscica, DO
Shalesh Gupta, MD	Kim Hillstrom	Madiha Kaleem, MBBS	Bruce Kovacs, MD
Larisa Gusovskaya	Makiko Hirai, MD	Craig Kalter, MD	Judy Kramer
Cristy Gustas, MD	Calvin Hobel, MD	John Kamp, MD	Robert Krasnick, MD
Edward Ha, MD	Douglas Hoffman, MD	Dimitrios Kamvysis, MD, PhD	Robert Krause, MD
Shoshana Haberman, MD, PhD	MaryAnne Hoffman-Przywara, ChE, BA, AA, RDMS	Krista Kant, MD	Joan Kreider, MD
Lawrence Haines, MD, MPH, RDMS	William Holcomb Jr, MD	Adib Karah	Karen Krieg, DO
Timothy Hall, PhD, FAIUM	David Holdt, MD	Ardeshir Karimi, MD	Mark Kristy, MD
Jonathan Halperin, MD	Robert Holland, MD	Barry Karpel, DO	Mitsuhiko Kubo, MD
Antoinette Ham, MD	Pamela Holley, RDMS	Namasivayam Karunanithy, MB, ChB, DRCOG, DMRD, FRCR	Kathleen Kuhlman, MD
Sheri Hamersley, MD	Heather Holmes, MD	Richard Kates, MD	Odin Kuiper, MD
William Hamilton, MD	John Holmes, MD, PC	David Kauffman, MD	Naveen Kumar, MD
Lynwood Hammers, DO	Nancy Hopkins	William Kaufman, DO	Koteswara Kunda, MD
Lee Ann Hammond, BSN, MBA, MD	Janet Horenstein, MD	Yoshio Kawamata	Liza Kunz, MD
Lewis Hamner III, MD	Theodore Hovick Jr, MD	Angela Kay, RN, RDMS	James Kurtzman, MD, FACOG
Ulrike Hamper, MD, MBA, FACR, FSRU, FAIUM	Bobby Howard, MD	Saka Kazeem, MD, FACE, ECNU	Sui Ping Kwong, RDMS
Lara Hanlon, MD	Thomas Howard, MD	Alena Kazlouskaya, RDMS	Lane Laboda, RDMS
Gina Hanna, MD	Thomas Howard Jr, MD, FACOG	Aliaksandr Kazlouski, MS	Lauren Ladd, MD
Regina Hansen, RDMS	John Hryshchuk	George Kazzi, MD, MBA	Maria Ladino-Torres, MD
Gail Hansen-Gaidulis, MD, FAIUM	Tsang Tang Hsieh, MD	Jeannette Keefe, RDMS, RVT, RT(R)(M)	Sherelle Laifer-Narin, MD, FAIUM
Robert Hanson, MD	Madeline Huang, MD, FRCP(C), DABR	Christine Keer, RDMS, RT	Faye Laing, MD, FAIUM
Natan Haratz-Rubinstein, MD	John Hughes, MD	Ian Kellman, MD	King Hei Stanley Lam, MBBS, MSc SM&HS, PGDIPMSM, RMSK
John Harding, MD	Christopher Huls, MD, MS	Michael Kelly, DO	Andi Lambert, RT(R), CBDT, RMSK
Renee Harding, RDMS	Roderick Hume Jr, MD	Karen Kennedy, MD	Edward Lampton Jr, MD
Joanie Hare, MD	Diana Hunt, RDMS, RT(R)	George Kennington, AS, RDMS	Laurie Landeen, MD, FACOG
Seemanthini Hariharan, MD	James Hwang, MD	Christy Kessen, RT(R)(M), RVT, RDMS	Heather Landers-Saltz, BA, AA
Lorie Harper, MD, MSCI	Charles Hyde, MD	Lawrence Kessler, PhD	Daniel Lankin, MD
James Harris, MD	Garrett Hyman, MD, MPH	Norman Kettner, DC, DACBR, FICC	Judith Lant, RT(R)(M), RDMS
Jeffrey Harris, MD	Eric Hyson, MD	Tarek Khalife, MD	D. Betsy Lantner, MD
Michael Harris, MD	Kenneth Iles, DC	Sadia Khan, MBBS	Michael Lao, MD
Miranda Harris-Glocker, MD	Gheorghe Iliev, MD, PhD	Aldo Khoury, MD, FACOG	Tanisha Larsen, RDMS, RT(R)
Herlof Harstad Sr	Marc Incerpi, MD	Thomas Khoury, MD, FACS, RVT	Janet Larson, MD, FACOG
David Hartge	Nanette Indudhara, BS	Bhupinder Kumar Khurana, MBBS, MD	Timothy Larson, MD
Janice Hartnett, MD	Maria Iparraguirre, MD	Michael Kicenuik, MD	Elena Last
Rebecca Haskett, RDMS, RVT	Theresa Irwin, RDMS, RVT, RDCS	Ania Kielar, MD, FRCP	Michele Lauria, MD
Toshiyuki Hata, MD, PhD	Yoshihiko Iwasa, MD, PhD	Denise Kieso, RDMS, RVT	Philip Lavin, PhD
Robert Hatch, MD	Patty Jackson, RDMS, RDCS, RVT	Robert Kiltz, MD	Michael Laymon, PT, DSc, OCS
Kay Hatton, NP, RDMS	Saundra Jackson, MD	David Kim, PhD	Sarah Lazar, MD
Melanie Hazen, APN, RDMS, BS	Ewa Jacunski, MD	Rosemary King	Mark Leber, MD, RDMS
Michael Heard, MD	Vikas Jadhav, MBBS, DMRD, MD, PhD, FICR, FIC	Andrea Kingsley	Lisa Lee, RDMS
Aimee Heeze, RDMS	Vanita Jain, MD	Stephen Kirk, MD	Maureen Lee, MD
Frederick Hegge, MD	Roger Jammal, MD	Mary Kirves	Melissa Lee, MD
Karen Hehnen, RDMS	Mussarat Jehan, MBBS	Siri Kjos, MD	Milton Lee, MD
Timothy Heiser, RDMS	Jamie Jenkins, MD	Laura Klein, MD	San-Kan Lee, MD, FAIUM
Krystal Hendricks, RDMS	Brian Jennings, DO	Carolyn Kline, MD, MPH	Thomas Leigh, MD
Harold Henry, MD	Chastity Jennings-Nunez, MD	Barry Knapp, MD, FACEP, RDMS	Johan Louis Leipoldt, MB, ChB, DOH
Nancy Henry-Socha, MD	Gary Jensen, MD	Robert Koby, MD	Amol Lele, MD, FACOG
Cynthia Herbert, RDMS, RDCS, RVT	Lars Jensen, MD	Andrew Kochan, MD	John Lenihan Jr, MD
Sergio Heredia, MD	Gary Joffe, MD	Sergei Kochkine, RDMS	Tiffanee Lenzi, MD, PhD
Arthur Hernandez, MD	Cherie Johnson, MD	Alexander Kofinas, MD	Keith Lescale, MD
Marta Hernanz-Schulman, MD	Jeffrey Johnson, MD	Alexandra Kogan, BA, RDMS	Anna Leung, MD
Kenneth Herr, MD	K. Paige Johnson, MD	Michael Kolios, PhD	Sally Le Van, RDMS
Howard Herrell, MD	Robin Johnson, RDMS	Yuko Kono, MD, PhD, FAIUM	Deborah Levine, MD, FAIUM
Oscar Herrera, MD	Susan Johnston, RDMS	Jerome Kopelman, MD	Alexander Levitov, MD, FCCP, FCCM, RDCS
Peter Heyl, MD	Frederick Jones, MD	Asteris Korantzis Sr, MD, PhD	Bernard Lewandowski, MD, FRCP, RVT, RDMS, MBA
Rachel Hidalgo, RDMS	Jeffrey Jones, MD		Dawnette Lewis, MD, MPH
Joseph Higgins Jr, MD, PhD	Oliver Jones, MD		
	Anthony Joseph, MD		



Mary Beth Lewis-Boardman, MD	Joseph Martin, MD	Subhash Mitra, MD, MPH	Mitchell Nutt, MD, RDMS
Mingde Li, PhD	Olympia Martinez, RT(R), RDMS	Jeanette Mladenovic, MD, MBA, MACP	Ogonna Nwawka, MD
Pai-Chi Li, PhD, FAIUM	Carl Martino, MD	Debra Mohr, RT, RDMS, BS	Janet O'Brien, RDMS, PA-C
Larisa Likver, MD	Subha Maruvada, PhD	Rafael Molina Jr, MD	Kathy O'Connell, MD
Kee-Hak Lim, MD	Josephine Mascia, RDMS	Ana Monteagudo, MD, RDMS, FAIUM	Sean O'Connor, MBBS
Christen LiMandri, MS, RDMS	Maria Mascola, MD, MPH	Jules Moodley, MD	Svein Odegaard, MD, PhD
G. Sharat Lin, PhD	Deirdre Masterton, MD	Ashley Moore, RDMS, RTR	Charles Odwin, BA, RDMS, PA-C
Cheryl Ann Lindstrom, MD	Dimitrios Mastrogiannis, MD, PhD	Christopher Moore, MD, RDMS, RDCS, FACEP	Paul Ogburn Jr, MD
Patrick Ling, MD, MPH, RMSK	Cherie Mathews, RDMS	Holly Moore, RDMS, RT(R)	Cherrie Ogin, RDMS, RVT
Glenn Lipton, MD	Nathan Mathews	Yuliana Moore	Oluseyi Ogunleye, MD
Andrew Liteplo, MD, RDMS, FACEP	Gail Matthews, MD	Doreen Morales, RT, RDMS	Joel Okazaki, MD
Christian Litton, MD	Cynthia Matthies, RDMS	Patrick Moran, DO	Ugo Okereke, MD, FACP
Peter Littrup, MD	Kelly Maurelus, MD	John Moreland Sr, RT (R), (CT), RDMS, RVS	Earle Oki, MD
Liping Liu, MD	Constance Maves, MD	Zaira Moreno, MD	Idowu Olanrewaju, MD
Lawrence Lo, MD, RDMS, FACEP	Lisa May, MD	Michael Moretti, MD	Chiou Li Ong, MBBS, FRCR
Mark Lockhart, MD, MPH, FAIUM	Donald Mayekawa, MD	Richard Moretuzzo, MD	Christopher O'Reilly-Green, MD
Joseph Lombardi, MD	Cyrus McCalla, MD	Brian Morgan, MD, PhD	Judith Ortman-Nabi, MD
Sherri Anne Longo, MD	W. Desmond McCallum, MD	Gail Morgan, MD	Newton Osborne, PhD, MD, MS
Cindy Lopez, RDMS	Georgette McCance, MD	Pablo Morikawa, MD, PhD	Elia Osorio, RN
Thomas Losure, DO	Timothy McCormack, MD	Fuminori Moriyasu, MD	Jorge Otero, MD, MSc, RDMS
Coreen Lowney, RDMS	Michael McCoy, MD	Marilyn Mueda, RDMS	William Ott, MD
Christina Lundborg, RDMS, RVT	Brian McCulloch, MD	Jean-Paul Muller, MD	Elizabeth Ottman, MD
Bridgette Lunsford, MAEd, RDMS, RVT	Dennis McDonald, MD	David Mundy Sr, MD	Catherine Overton, RDMS
Pamela Lyon, RDMS, RRT	Caitlin McGregor, MD	Anna Munoz-Lopez	Tulin Ozcan, MD
Deborah Mabin, MBChB, FFRad(D)SA, FRCPC, CCPE	Thomas McGunigal, MD	Amie Murphy, RDMS	Josephine Ozoemena, MBBS
Christian Macedonia, MD	Susan McKechnie	Heather Murphy, RDMS	Thierry Pache, MD, PhD
Laurence Mack, MD	Jennifer McKenna, MD, FACOG	James Murphy, MD	Natalia Pak
Charles Macri, MD	Gina McNeill, RDMS	Johanne Murphy, RDMS	Matthew Palmer, DO
Ernest Madsen, PhD, FAIUM	Jakob McSparron, MD	Joseph Muscat, MD	Sandesh Pandit, MD
Kazuo Maeda, MD, PhD, FAIUM	Mary Meadows, RT(R), RDMS	Casimir Muszynski Sr, MD	Pravati Panigrahi, MD
Paul Maertens, MD	Thomas Mechas, MD, FACOG	Samuel Nagle, MS	Emmanuelle Paré, MD, FRCSC
Everett Magann, MD	Jose Medina, MD, FACR	Dianne Nagy, RNC NP	Luis Paredes Sr
David Magarik, MD	Heidi Meinz, MD	Renuka Naidu, MBBS, RDMS	Don Parker, MBA, MBT
Ruth Maher, PT, PhD, DPT, WCS	Dennis Meister, BSE	Dale Nairn, RDMS	Julie Parrow, RDMS, RDCS, RTR
Denise Main, MD	Israel Meizner, MD, FAIUM	Miwa Naito	Breanna Parsons
Sarah Mainguy, MD	Marianne Melnik, MD	Dean Nakamoto, MD	Sherri Parsons
Patricia Ann Malek, RN, FRCN	Paula Melone, DO	Linda Nall, MD	Steve Parsons, MD, FRCSC
Srini Malini, MD	Aaron Mendel, MD	Hitesh Narain, MD	Suean Pascoe
Robert Malone, MD	Ernesto Mendoza, MD	Jose Naranjo, MD	Anit Patel, MD
Cristiana Malorgio	John Mercer, MD	Joel Nations, MD, MBA	Atul Patel, MD, MHSA
Ravi Managuli, PhD, RDMS	Michelle Mercier, RTR	Kentia Naud, RDMS, MD, FRCSC	Avanee Patel, MD, FACOG
Arthur Mandelin, MD, PhD	Margret Mergelsberg, MD	Innocent Ndubuisi, BS, RT(R), RDMS, RDCS, RVT	Ramesh Patel, MD
Bikaramjit Mann, MD	Jennifer Merriman, MD	Gregory Neal, MD	Swati Patel, RDMS, RVT
Danielle Mann, DO	April Merritt, MD	Joy Neimiller, RT, RDMS	Vinu Patel, MD
Gregory Mann, DO	Daniel Merton, BS, RDMS, FSDMS, FAIUM	Renee Nelson, MD	Harold Pedersen, BA, RDMS
Maria Manning, MD	Michael Mesbah, MD	Tee Nelson	John Pellerito, MD, FACR, FAIUM, FSRU
Anita Manogura, MD	Julie Meyer	Amen Ness, MD	Guillermo Pelletier
Luis Mansilla, RDMS	Patrick Meyers, BS, RDMS, RDCS, RVT	Roxana Neyra, MD	Suzette Peltier, MD
Darlene Mansueto, RDMS	Hugh Miller, MD	Chris Nguyen, PhD	Linda Pendziwol, RDMS
Peter Maran, MD	Joyce Miller, EdD, RDMS	Truong Chinh Nguyen, MD	Rebecca Pennell, MD
Susan Marcelli, MD	Sheila Miller	Terry Nicola, MD, MS	James Pennington, RDMS
Michael Marcotte, MD	Tammy Miller-Sego, RDMS, RVT	Laurent Nicolov, MD	Phillips Perera, MD
Joseph Markee, MD, FACOG	Mary Ann Milliren-Stryker, RT, RDMS	Kathy Nightingale, PhD	Christian Perez, MD, FACOG
Michael Marohn, AB, DO	Claire Mills, RDMS, RVT	Makoto Niizawa, MD	James Perez, DO
Clifford Marshall, MD	Gerald Minkowitz, MD	Michael Nimaroff, MD	Jorge Permanyer Barrier, MD
Ernest Marshall, MD	Marta Minnerop, MD	J. Douglas Nisbet II, MD	Robert Petite, BS, RDMS, RDCS
Randolph Marshall, MD	Maria Mintcheva, RDMS	Ali Noor, MD	Albina Petrosian
Michelle Martel, MD	Paoletta Mirk, MD	Dawn Nutt, RT, RDMS	Ruth Petrucha, MD
Jennifer Martin, MD	Carol Mitchell, PhD, RDMS, RDCS, RVT, RT(R)		Helder Pezzin
Jerry Martin, MD			Pamela Phayre, RVT
			Douglas Phillips, MD

Edward Phillips, MD  
Catherine Piccoli, MD  
Jason Picconi, MD, PhD  
Kristal Pickron, RDMS  
Debra Piehl, MD  
Cynthia Pierce  
Guy Pierno, RT  
Jorge Pineda, MD  
Steven Pinheiro, MD  
Nelangi Pinto, MD, MS  
Cesar Pizarro, MD  
James Place, MD  
Elizabeth Platz, MD  
Christopher Plummer, DO, FACOG  
Rubem Pochaczewsky, MD  
Ann Podrasky, MD  
Robin Poe-Zeigler, MD, FACOG  
Gustavo Poggio, MD  
Joseph Polak, MD, MPH, FAIUM  
Scott Pollock, MD  
Adrian Pop, MD  
Iris Pope, BS, RRT, RDMS, RVT, PhD  
Julian Portelli  
Srinivasa Potluri, MD  
John Powell, MD  
Kelli Powell, RDMS, FAIUM  
Narayana Prasad, MD, MS, RDMS, RDCS, RVT, RMSK, FASE  
Uma Prasad, MBBS, MD  
Richard Price, MD  
E. Rebecca Pschirrer, MD, MPH  
Karoline Puder, MD  
Satish Puri, MBBS, DMRD, MBA, RPVI, RVT, RDMS  
Elizabeth Puscheck, MD, MS  
Sherri Putterman, MD  
Scott Puza, MD  
Daniel Quenneville, MD  
Kathy Quenneville, BS, RMSK, RDMS, RT(R)  
Valerie Quick, RDCS, RDMS, FASE  
Francisco Quintana-Gonzalez  
Yolanda Rabello, RDMS  
Irina Radionova  
Karen Raimer, MD  
Cherie Ralfs, RTR, RDMS, RVT, RCVT, RDCS  
Shankar Ramamurthy, MD, DMRD  
Gladys Ramos, MD  
Alberto Ramos Cruz, MD  
Jagpal Rana, MD  
Louise Rang, MD, FRCPC, RDMS  
Sharon Ransom, MD  
Olga Rasmussen, RDMS  
Naina Rastalsky  
Andrei Rebarber, MD  
Victor Reddick, RDMS, RDCS, RT, FAIUM  
Stephen Redding, MD  
Gregory Reid, MD  
Christine Reilly, RT, RDMS  
Dana Resop, MD  
Carlos Reyes, MD  
Cecily Reynolds, MD, MS  
Daniel Rickey, PhD  
Joey Ridings, RDCS, RVT  
Catherine Rienzo, MS, RT(R), RDMS, FSDMS  
Sarah Riffle, RT(R), RDMS, RVT  
Colin Rigney, PT, DPT, OCS  
Christopher Rigsby, MD  
Brian Rinehart, MD  
Nancy Rinke, RDMS, RVT  
Eric Rittenhouse, MD  
Manuel Rivera-Alsina, MD, MBA, FACOG  
Kimberly Roberts, MD  
Andrew Robertson, MD  
Charlah Robinson, MD  
Julian Robinson, MD  
Kathryn Robinson, MD  
Hope Robinson-Beverly, RT(R), RDMS  
Thomas Rodenberg  
M. Hellen Rodriguez, MD  
Mary Rodriguez, CAE  
Jeffrey Rodzak, MD  
Matthew Rogalski, MD, FACOG  
Christine Rogers, BS  
Kirsten Rojas, MD  
Florence Rolston, MD  
Ashley Roman, MD, MPH  
Nina Romanova, MD  
David Rosado, MD  
Angel Rosas, MD, FACOG  
Howard Rose, DO  
Doron Rosen, MD  
Emily Rosenbush, MD  
Kendra Ross, MD  
Sharon Rosser, DsC-PA  
Brenda Ross-Shelton, MD  
Glenn Rouse, MD  
Susan Rowling, MD  
Thomas Rubeo Jr, MD  
Susan Rubinoff, MD  
Perry Rudich, MD  
Richard Rudolph, MD  
James Ruiz, MD  
Juan Ruiz  
Miguel Ruiz, RDMS, RVT  
Tatjana Rundek, MD, PhD  
Gilles Russ  
Shahnoz Rustamova, MD  
Constantine Saadeh, MD, FACP, FACR  
Rudy Sabbagha, MD, FAIUM  
Leo Sabiniano, RDMS  
Glynis Sacks-Sandler, MBBCh  
Mahnaz Saeed, MBBS, FCPS  
David Sahn, MD, FAIUM  
Fumikazu Sakai, MD  
Lubna Salam  
Sharon Salamat, MD, PhD  
Mustafa Salih  
Azen Salim, MD  
Fawwaz Salman, MD  
Caryl Salomon, MD  
Michael Saltzburg, DO  
Daniel Saltzman, MD  
Hera Sambaziotis, MD, MPH, FACOG  
Lauren Samperi, RT(R), RDMS, RVT  
Karen Sanchez, BA, RDCS, AE, PE  
Norberto Sanchez, MD  
Lavinia Santiago, RDMS  
Marlaina Santiago, RDMS  
Joaquin Santolaya-Forgas, MD, PhD  
Rigoberto Santos-Ramos, MD  
Karen Saravanos, MD  
Bani Sarma, MD  
Albert Sarno Jr, MD, MPH  
Norman Sato, MD  
Takahiro Sato  
Hemant Satpathy, MD  
Colleen Saunders, AA, RDMS  
Kelly Sbuttoni, RDMS  
Aaron Scaife, MD  
Lisa Scales, MD  
Shaundra Schaefer  
Adriana Schaufelberger, MD, MPH  
Andrea Scherer, RDMS  
Mary Schmidt  
Ingrid Schneider, MD  
Neil Schneider, MD  
Ronald Schneider, RDMS  
Thomas Schramm, MD  
Stephen Schuermann, MD  
Patrick Schuette, MD, FACP, FACR  
Valerie Schulz, MD  
Heinz Schwab, BSc  
Joyce Schwartz, RDMS, RVT, AS  
Wade Schwendemann, MD  
Susan Schy, MD  
Anthony Sciscione, DO  
Cherri Scott, RDMS, RVT  
Merry Sebelik, MD, FACS  
Pedro Segarra, MD  
Jose Segovia Garcia  
Knarik Sekhleyan  
Josepha Seletz, MD  
Shyamashree Sengupta, MD, FACOG  
Lidia Sergueeva  
Gretchen Severns, RDMS, RT  
Mehnaz Shafiq, MBBS  
Sherry Shang, MD  
Shane Shapiro, MD  
Ralph Sharman, MD  
Kathryn Shaw, MD  
Candice Shea, MD  
Brent Shelton, MD, FACOG  
Claudette Shephard, MD  
Julie Shih, MD, FACOG  
Takashi Shimizu, MD, PhD  
Norio Shinozuka, MD, PhD  
Arnold Shkolnik, MD, FAIUM  
Philip Shlossman, MD  
Anna Shu  
Janie Shunk, RDMS  
Tariq Siddiqi, MD, FAIUM  
Ravinder Sidhu, MD  
John Siefert, MD  
Fred Siegel, MD  
Inez Silva, BS, RDMS  
Rogerio Silva, MD  
Tori Silva, RN  
Robert Silverman, MD  
Ronald Silverman, PhD, FAIUM  
Julian Simmons, MD  
Mark Simonelli, MD  
W. Caldwell Sims, MD  
Jorge Sinclair, MD  
Kathleen Singer, RDMS  
Shailini Singh, MD, FRCS(C), FACOG  
Rachel Singletary, RDMS  
Elena Sinkovskaya, MD, PhD, RDMS, RDCS  
Natalia Sivenkova  
Nicholas Skelton, BS, RDCS  
Dan Skyba, PhD  
Pauline Sleder, MD, MA  
Charles Slocumb, MD  
Dana Smetherman, MD  
Kathleen Smith, MD, PhD, FACOG  
Stephen Smith, MD  
Harry Snady, MD, PhD  
Stephen Snow, MD  
Sachin Solanki  
Lisa Soldat, MD, MS, FAAFP  
Julia Solomon, MD, CM, FACOG  
Tara Sosna, MD  
Zachary Soucy, DO  
Robert Spaulding, MS  
Ana Spence, MD  
Andrew Spencer, MD  
Robert Spicer, MD  
Neil Spiegel, DO  
Maja Stachura, MD, FRCPC  
Melinda Staiger, MD, BS, FACR  
Jami Star, MD  
Randall Starcher, MD  
Sidney Starley, MD  
Ralph Steiger, MD  
Janet Stein, MD  
Marjorie Stein, MD  
Michelle Steinbach, RT(R), RDMS  
Michel-Patrick Steinmetz  
Virginia Stewart, MD, RDMS, RDCS, RMSK  
Sean Stickles, MD  
Lori Stolz, MD  
James Stouffer, PhD, MS, FAIUM  
Carol Stull, MD  
Hoda Sturman, AA, RT, RDMS  
Adriana Suarez, MD  
Ian Suchet, MBBCh, FRCPC  
Yasuaki Sumino, PhD  
Donna Summers, RDMS  
Susan Sunyak, RDMS, RTR

Betsy Sussman, MD	Katie Vanuden, RT(R), RDMS	Trisha Wilson, RT(R), RDMS (AB)
Julian Suszanski, MB, BCh, BAO	Sue Van Zanten	Stephanie Winfrey, RDMS
Donna Jean Sweetland, MD	Tomy Varghese, PhD, FAIUM	Michael Wise, DVM
Manuel Sy, MD	Marie Vartolo, MD	Constance Witte, RTR, RDMS
Humera Syeda, MD	Jean-Claude Veille, MD	Lynlee Wolfe, MD
Alain Szyller, MD	Claudia Velasco, RDMS, RVT	Angela Wong, BS, RDMS, RDCS
Claudia Taboada, DO	Kathy Velekkakan, RDMS	Hong Soo Wong, MBBS, MMedSc
Michel Taillefer	Ivana Vettraino, MD	Roberta Wong, BS, RDMS, RDCS
Filemon Tan, MD, PhD	Yvan Vial, MD	James Woods Jr, MD
Julierut Tantibhedhyangkul, MD	Lisa Vigue, MD	Tatyana Wright, RDMS
Nakhle Tarazi, MD	Luis Villatoro Hernandez	Stanley Wu, MD
Lucille Taverna, BS, MD	Anthony Vintzileos, MD, FAIUM	Corrie Yablon, MD
Marcos Tawil, MD	Richard Viscarello Jr, MD, FACOG	Laura Yates, RDMS, RVT, RT(R)
Barbara Taylor, MD, FACR	Joni Voss, RT(R), RDMS, RVT	Amaryllis Yazon, MD
Nataliya Tchertchenko, RDMS	Brent Wagner, MD	Bruce Young, MD
Nathan Teismann, MD	Jason Wagner, MD	Nighat Younus, MBBS
Ariel Teitel, MD, MBA	Philip Wagner, MD	Salwa Youssef, RDMS, RVT
Jorge Telles	Camil Walker, MD	Wai Kuen Vivien Yu
Megan Temp, MD	Susan Walker, RDMS	Theresa Yuh, MD
Rebecca Teng, MD	Eileen Wang, MD	Mark Yuhasz, MD, FACR
William Terry, MD, FACOG	Xiaoli Wang	David Zalenski, MD
Parmelee Thatcher, MD	Barbara Ward, MD	Thomas Zarlingo, MD, FACOG,
Dan Thomason, MD	James Warshaw, MD, PhD, ECNU	FACS
Kai Thomenius, PhD, FAIUM	Antoinina Watkins, MD	Jill Zavitsky, RT, RDMS
Michael Thompson, MPH, RDMS,	Howard Weber, MD, FAAP, FACC,	Carolyn Zelop, MD
RVT, RDCS, RPhS, RCS, RVS	FSCAI	Jill Zimmerman, RDMS
Noel Thompson, MD, MS, BA	Joshua Weidman, MD	Mary Zozulin, MD, FACOG, FACS
Thomas Thompson, MD	Katharine Weinstock, MD	Margie Zugaro, RDMS
Stephen Thorn, MD, FACOG	Judith Weiss, RDMS, BA	Laura Zuidema, MD
Michael Thornton, MSc	Lori Weiss, RDMS	Patricia Zylman, MD
Toccara Threatt, BS, RDMS	Patricia Weiss, AAS, RDMS	
Shawn Tierney, RMSK, DC	Stan Weiss, MD	
Cheryl Timblin, RDMS	Murray Weissmann, MD	
Arkom Tivorsak, MD	Lara Welch, RDMS	
Katie Toft, MD	Holly Wells, MD, FRCP(C), ABR	
Ants Toi, MD, FRCP, FAIUM	Rodney Wells, MD, FACOG	
Madonna Tomani, MD, FACOG	William Wells, MD	
Denise Tonzola, MD	Erika Werner, MD, MS	
Felicia Toreno, PhD, RDMS, RDCS,	Ellen Wetter, MD	
ROUB, RVT	Paul Wexler, MD	
Debra Tracy, RT, RDMS	LeRoy White, MD	
Donald Tradup, RDMS, RT	Wendy White, MD	
Hung Tran, RDMS, RVT, RDCS	Kari Whitley, MD	
Nga Tran, BS, RDMS, RVT, RT(R)	Craig Whitmore, MD	
Dara Treadwell, BS, RT(R)(M),	Didi Whitten, RDMS	
RDMS	Rita Whitton, RDMS	
Lynn Trepp, RT, RDMS	Willyarto Wibisono, MD, FAIUM	
Eric Trygstad, MD	Marcin Wiechec	
Hideki Tsuge	Jon Wiesman	
Jan Tuma	Thomas Wigton, MD	
Ilan Tur-Kaspa, MD	Martin Wilcox, BSEE	
John Turocy, MD, MS	Thomas Wilkins, MD	
Cathy Tyma, MD	Aaron Williams, DO	
Lindsey Underwood, RT(R), CBDT,	John Williams III, MD	
RMSK	Keith Williams, MBBS, DABOG,	
Evan Unger, MD	MBA	
William Unwin, MD	Margaret Williams, RT, RDMS	
Mary Jean Uy-Kroh, MD	Michael Williams, MD	
Ray Valdepena, RDMS	Terri Williams-Weekes, MD	
Carmen Valderrabano, MD	Melissa Willis, BS, RT(R), RDMS	
Peter Van Dell, MD	Cielito Wills, BA, RVT, RDMS	
Kristina Vandermark, MD	Donna Wilson	
Peter Van Eerden, MD	Stephanie Wilson, MD, MS	

# 2016 Scientific Program



\*Presenter of scientific paper with more than 1 author.

## SCIENTIFIC SESSIONS

SATURDAY, MARCH 19, 2016, 11:00 AM-12:30 PM

### Basic Science: Bioeffects and Instrumentation

*Moderator: Keith Wear, PhD*

#### 2385072 Hermite Function Pulses for Scatterer Identification

**Kevin Parker**

*Electrical and Computer Engineering, University of Rochester, Rochester, NY USA*

**Objectives:** Different classes of scatterers have characteristic frequency dependences, from nearly flat (in the case of ideal specular reflections from surfaces) to Rayleigh scattering from subresolvable scatterers. The Gaussian-weighted hermite polynomials have a power law relation in the frequency domain and may be useful for assessment of the type of reflected signal in pulse-echo imaging.

**Methods:** The  $n$ th successive differentiation of the Gaussian pulse  $G = \exp(-t^2)$  generates the  $n$ th order Hermite polynomial (Poularikas, 2010). The function  $H_n(t)G$  resembles a typical broadband pulse. Assuming a pulse-echo system has a round-trip impulse response of  $A_0 H_n(t)G$ , then we expect that a reflection from a step function of acoustic impedance will produce a corresponding received echo proportional to  $G H_n(t)$ . However, a thin layer of higher impedance would have a discrete doublet (derivative) in impedance and an echo proportional to  $G H'_n(t)$  by the derivative nature of the Hermite polynomials. Finally, a small scatterer or incoherent cloud of small scatterers would exhibit a second derivative behavior and return an echo proportional to  $G H''_n(t)$ . In this framework, the identification task is simply to classify echoes by similarity to either  $G H_n(t)$ , or  $G H'_n(t)$ , or  $G H''_n(t)$ .

**Results:** To demonstrate the potential of this approach to identify properties that are otherwise hidden in the conventional B-scan, simulations of different classes of scatterers are examined. Conventional imaging parameters are used or a  $G H_n(t)$  round-trip impulse response scaled to a peak frequency of 5 MHz. Scatter types include a single impulse, a discrete doublet (axially), and the left discrete triplet. Thus, the scatterers approximately produce reflections that correspond to the pulse, the derivative of the pulse, and the second derivative of the pulse with respect to time. The resulting B-scan image is examined, and echoes can be correctly classified according to their class. Tissue scans also demonstrate groups of echoes separated by Hermite order  $H_n$ .

**Conclusions:** A theoretical framework is introduced where reflections are characterized by their similarity to  $n$ th order Hermite polynomials.

#### 2385179 Lower Bound on Estimation Variance of the Ultrasonic Attenuation Coefficient Using the Reference Phantom Method

**Kayvan Samimi,\* Tomy Varghese**

*Medical Physics, University of Wisconsin-Madison, Madison, WI USA*

**Objectives:** The objective of this study was to derive a theoretical lower bound for the variance of attenuation estimates obtained by spectral difference methods using a reference tissue-mimicking phantom (TMP). Specifically, this theoretical model would formulate a lower bound as a function of processing parameters associated with the estimation method.

**Methods:** An exponential probability density function (pdf) was utilized to model frequency-dependent backscatter under the assumption of diffuse scattering. This pdf was translated into a probabilis-

tic model of the average sample power spectrum normalized by the average reference TMP power spectrum for a 2D block of the radiofrequency (RF) data frame. The Fisher information function for the unknown sample attenuation was derived from the joint power-spectral pdf of several axially consecutive data blocks, yielding the Cramér-Rao lower bound (CRLB) for the variance of an unbiased estimator of the sample attenuation. RF data from simulated and experimentally scanned TMP were processed according to the reference phantom method (RPM) to verify the lower bound. The estimation standard deviation (STD) for the sample attenuation was measured for different processing parameters. These included data block window length from 3 to 17 mm, data block width from 10 to 100 A-lines, and number of RF data blocks per attenuation estimation region of interest from 3 to 10. Data spanned the frequency range from 1 to 20 MHz.

**Results:** Mean and STD of the estimated attenuation coefficients were calculated for different values of processing parameters. The resulting STD curves were observed to lie above the theoretical lower bound curves, thus experimentally verifying the validity of the derived bounds.

**Conclusions:** This theoretical framework benefits tissue characterization efforts by isolating processing parameter ranges that could provide required precision levels in estimation of ultrasonic attenuation using spectral difference methods. (Supported in part by National Institutes of Health grants R01 CA112192 and T32 CA09206-36A1.)

#### 2385495 Using a Gamma Mixture Model for Estimating Cervical Attenuation

**Viksit Kumar,<sup>1,2\*</sup> Timothy Bigelow<sup>1</sup>**

*<sup>1</sup>Electrical and Computer Engineering, Mechanical Engineering, Iowa State University, Ames, IA USA; <sup>2</sup>Ultrasound Imaging Lab, Mayo Clinic, Rochester, MN USA*

**Objectives:** Attenuation is a quantitative ultrasound parameter that can provide insight into the tissue microstructure. Heterogeneity of the tissue can bias attenuation algorithms; hence, techniques must be developed to identify regions of similar backscatter (homogenous regions). Speckle properties can be used to identify valid attenuation estimates. For a fully developed and unresolved speckle pattern, a gamma model has been shown to be the best empirical model for speckle distribution fitting.

**Methods:** Three-layered phantoms were simulated with different backscattering properties. In phantom 1, scatter size was varied, whereas the number density was varied for phantom 2. A gamma mixture model (GMM) was implemented using the expectation maximization algorithm to distinguish regions of varying backscatter. Attenuation estimates were then obtained using the spectral log difference algorithm. In addition, 64 pregnant women underwent transvaginal ultrasound examinations. Ultrasound data were obtained at 5 different time points (20, 24, 28, 32, and 36) during the gestation period. The spectral log difference algorithm was used to calculate attenuation values for each scan after segmentation of homogenous regions using GMM.

**Results:** GMM was able to distinguish between regions of varying scatter size and varying number density in simulations and phantom experiments. For varying scatter size, the standard deviation decreased by a factor of 2. GMM segmentation was also applied to the cervical data to identify regions of similar backscatter. Receiver operator characteristic (ROC) curves were plotted to compare the improvement of attenuation estimates with GMM and without GMM. The area under the ROC curve increased from 0.56 to 0.80.

**Conclusions:** GMM can be used to identify regions of similar backscatter. Attenuation estimation algorithms are less biased and have lower standard deviations when the attenuation-map pixel is homogenous. GMM can be used in congruence with attenuation values to get better estimates of attenuation values by throwing out invalid attenuation estimates.

### 2394302 Differentiation of Breast Lesions Using Statistics of Backscattered Echoes Combined With the Breast Imaging Reporting and Data System

Hanna Piotrkowska-Wroblewska,\* Andrzej Nowicki, Katarzyna Dobruch-Sobczak, Jerzy Litniewski

Ultrasound, Institute of Fundamental Technological Research, Warsaw, Poland

**Objectives:** The aim of the study was finding the relationship between Breast Imaging Reporting and Data System (BI-RADS) classification combined with K, K-homodyne, and Nakagami statistics of echoes backscattered in the breast tissue and histologic data.

**Methods:** A total of 220 breast lesions were examined: 66 malignant and 154 benign. Both the radiofrequency (RF) echo signal and B-mode images from the lesions and surrounding tissue were recorded. The analysis method was based on combining data from BI-RADS classification and statistical parameters. Two types of data, a traditional B-mode image and a set of RF echo lines, were acquired for the breast regions where the tumors were localized and from the healthy regions of the breast tissues. One image consists of up to 500 RF echo lines. Influence of the attenuation on RF echoes was compensated prior to the statistical properties of the breast backscatter. For every sub-region of interest (ROI) region (0.25 mm<sup>2</sup>), the mean value of echo envelopes was calculated. Next, the values of the envelopes inside each square subregion were divided by the mean value of the envelope, which was determined for this area. In the next step, each lesion was divided into N sub-ROIs covering the lesion. The quantitative parameters were calculated for sub-ROIs inside the lesion and for surrounding tissues. Based on the distribution parameters, the set of 21 parameters was defined.

**Results:** When only B-mode imaging was used with the cutoff at BI-RADS 3/4a, all malignant lesions were diagnosed correctly; however, 46 benign lesions were sent for biopsy unnecessarily. The best result, obtained for K distribution showed a sum of specificity and sensitivity equal to 164.79%. Combined BI-RADS classification and statistics showed 96.88% sensitivity with specificity equal to 65.33%, which means the number of lesions that were biopsied decreased from 46 to 35.

**Conclusions:** Combining quantitative ultrasound with BI-RADS classification seems to be encouraging. Analysis of 220 breast lesions showed that the use of quantitative parameters together with BI-RADS classification categories improved distinguishing benign from malignant lesions and allowed us to reduce the number of biopsies by almost 25%, compared to procedures based on B-mode images only.

### 2394384 Shear Rate Normalized Flow-Mediated Vasodilation of the Radial Artery

Andrzej Nowicki<sup>1,\*</sup>, Wojciech Secomski<sup>1</sup>, Zbigniew Trawinski<sup>2</sup>, Robert Olszewski<sup>2</sup>

<sup>1</sup>Ultrasound, Institute of Fundamental Technological Research, Warsaw, Poland; <sup>2</sup>Cardiology, Military Institute of Medicine, Warsaw, Poland

**Objectives:** Preceding atherosclerosis is endothelial dysfunction. There is therefore interest in the application of noninvasive clinical tools to assess endothelial function. There are commercially available ultrasound scanners to measure flow-mediated vasodilatation (FMD) of the brachial artery using 10–12-MHz linear array probes; however, the precision in estimating artery dilation does not exceed 0.2 mm, far beyond the required one. To improve the axial resolution, we have used a SonixTouch-Research ultrasound scanner (Analogic) with a 20-MHz linear array to measure the dilation of the radial artery. FMD results were next normalized to the accumulated shear rate (SR<sub>AUC</sub>) recorded using 20-MHz pulses Doppler attached to the linear array transducer.

**Methods:** Eighteen healthy volunteers and 3 volunteers with a minor cardiac accident were examined. The radial artery reactive response (RARR) was provoked by 5-minute artery ischemia through the inflated

pressure cuff on the forearm. A B-scan of the radial artery was recorded for 2 minutes after cuff release. During this time, the maximum flow velocity ( $V_{max}$ ) along the central stream was also acquired. The normalization of FMD to shear is done by dividing peak FMD by the accumulated value of shear rate area under the curve SR<sub>AUC</sub> calculated for the time span between releasing the cuff and peak dilation. The SR<sub>AUC</sub> was calculated as  $SR_{AUC} = 6V_{max}/D$ , assuming a slightly flattened flow profile.

**Results:** The measured initial internal radial artery diameter was in the range of 1.59–2.35 mm; the maximum diameter of 2.01–2.60 mm was observed 35–55 seconds after releasing the cuff. In a limited number (18) of examined young healthy patients, the FMD<sub>SR</sub> was in the range from 7.8–9.9 in arbitrary units. In older patients with a minor cardiac history, the normalized FMD<sub>SR</sub> was clearly lower, 6.8–7.6.

**Conclusions:** The radial FMD using 20-MHz imaging/Doppler equipment has over 2 times better resolution than the resolution obtained using 7–10-MHz brachial scanning. The normalized FMD of radial artery RARR in our group was 13%–28% and can be an alternative to the brachial FMD where the precision of measurements is lower and the diameter dilation does not exceed 7%–10%.

## Cardiovascular Ultrasound

Moderator: M. Robert De Jong, RDMS, RDCS, RVT

### 2361109 Will the Next Generation of Hospitalists Use Ultrasound in Practice? Observations Regarding Use of a Pocket-Sized Ultrasound Device by Residents During a Hospitalist Rotation

Benjamin Tsai

Internal Medicine, Scripps Mercy Hospital, San Diego, CA USA

**Objectives:** Although a pocket-sized ultrasound device (PSD) can augment cardiac physical examination, actual use on patients requires a perception of diagnostic need, a belief in one's skills, and convenience. We sought to observe the pattern of autonomous use and perceived clinical utility of a PSD when carried by on-call internal medicine residents (MDs).

**Methods:** We interviewed 14 consecutive MDs, formally trained in a cardiac limited ultrasound exam (CLUE), who carried a PSD for use at their own discretion during a busy night hospitalist call rotation. After a shift, MDs reported their use of the PSD with regard to indications, deterring factors, and difficulties in imaging. A separate detailed analysis was performed with a single MD instructed to utilize the PSD on every admission to compare the proportion of abnormal CLUEs and clinical utility in patients with and without perceived indications. Clinical utility was considered present when changes in management or significant reassurance were attributable to PSD use. Proportions were compared using 95% confidence intervals and a test of proportions.

**Results:** MDs admitted 243 patients (mean age, 54 years; range, 18–91 years) during 48 shifts. CLUE was felt to be indicated during 107/243 (44%) admitting physicals. MDs elected not to scan 136 patients due to lack of perceived indications (89 patients; 65.4%), time constraints (22 patients; 16.2%), or uncooperative patients (25 patients; 18.4%) and considered 17% of CLUE views technically difficult. In the detailed analysis (n = 71), the MD felt CLUE would have been indicated vs not-indicated in 32 (45%) vs 39 (55%), with abnormality rates of 50% (32.7%, 66%) vs 20.5% (7.8%, 33.2%) ( $P < .05$ ) and clinical utility of 28.1% (12.5%, 43.7%) vs 15.4% (4.1%, 26.7%) ( $P =$  not significant), respectively.

**Conclusions:** On a hospitalist rotation, residents frequently used ultrasound in initial assessment, and, in a detailed analysis, a considerable rate of abnormalities and management changes exist in patients with and without perceived indications. Augmenting patient evaluation with ultrasound may be a desired technique of hospitalists in the future.

# 2371987 Coronary Calcium Volume Measurement in a Diabetic Cohort Using Intravascular Ultrasound Videos: A Comparative Study

Tadashi Araki<sup>2</sup>, Sumit Banchhor<sup>3</sup>, Narendra Londhe<sup>3</sup>, Nobutaka Ikeda<sup>4</sup>, Petia Radeva<sup>5</sup>, Devarshi Shukla<sup>3</sup>, Luca Saba<sup>6</sup>, Antonella Balestrieri<sup>7</sup>, Andrew Nicolaides<sup>8</sup>, Shoaib Shafique<sup>9</sup>, John Laird<sup>10</sup>, Jasjit Suri<sup>1\*</sup>

<sup>1</sup>Electrical Engineering, University of Idaho (Affiliate), Pocatello ID, USA; <sup>2</sup>Electrical Engineering, AtheroPoint, LLC, Roseville, CA USA; <sup>3</sup>Division of Cardiovascular Medicine, Toho University Ohashi Medical Center, Tokyo, Japan; <sup>4</sup>Electrical Engineering, NIT Raipur, Raipur, Chhattisgarh, India; <sup>5</sup>Cardiovascular Medicine, National Center for Global Health and Medicine, Tokyo, Japan; <sup>6</sup>Digestive System Research Unit, Hospital Vall d'Hebron, Barcelona, Spain; <sup>7</sup>Azienda Ospedaliero Universitaria di Cagliari, Polo di Monserrato; Università di Cagliari, Monserrato, Italy; <sup>8</sup>Dipartimento di Scienze Mediche, Università di Cagliari, Cagliari, Italy; <sup>9</sup>Vascular Screening and Diagnostic Centre London, and Department of Biological Sciences University of Cyprus, Nicosia, Cyprus; <sup>10</sup>CorVasc Vascular Laboratory, Indianapolis, IN USA; <sup>10</sup>UC Davis Vascular Center, University of California, Davis, CA USA

**Objectives:** The planning of percutaneous coronary interventional procedures requires a quantitative assessment of the calcified volume in atherosclerotic wall. The objective of this study is to automatically measure the calcium volume from intravascular ultrasound (IVUS) videos in a diabetic cohort with Japanese ethnicity.

**Methods:** Fifteen patients (14 M/1 F; age of 67 ± 11 years), Institutional Review Board approved, Toho University, written informed consent, consisting of 30,600 coronary IVUS frames were collected using a 40-MHz IVUS catheter (Atlantis SR Pro, Boston Scientific, pullback speed of 0.5 mm/s). The mean hemoglobin, total Cholesterol, low-density lipoprotein, high-density lipoprotein, and percentage smokers were 5.89 ± 1.05 g/dL, 165 ± 20 mg/dL, 95 ± 23 mg/dL, 49 ± 13 mg/dL, and 46.6%, respectively. Lesion locations: 7 patients had a proximal lesion location, 4 at a middle and 4 at a distal location. The following locations were observed on calcification: 8 patients on left anterior descending, 4 on right ascending, 2 on left circumflex and 1 on left main. Three automated soft computing fuzzy pixel classification techniques, namely, fuzzy C-means (FCM), K-means, and hidden Markov random field (HMRF), were designed for automated extraction of calcium regions in above the frames and volume measured. The above 3 methods were benchmarked against a previously developed threshold-based method.

**Results:** The mean calcium volumes for FCM, K-means, HMRF, and threshold-based methods were 37.84 ± 17.38, 27.79 ± 10.94, 46.44 ± 19.13 mm<sup>3</sup>, and 35.92 ± 16.44 mm<sup>3</sup>, respectively. Coefficients of correlation of these 3 automated methods against the threshold-based method were 0.99, 0.96, and 0.95, respectively. Statistical tests such as the Student *t* test, *z* test, and Wilcoxon test were also performed, demonstrating consistency and reliability. K-mean showed the highest accuracy of 92.80% when compared against the expert.

**Conclusions:** We demonstrated 3 automated techniques for coronary calcium volume measurement using IVUS videos on a Japanese diabetic cohort. K-means showed the best performance. We validated our system against the expert's reading and performed the 3 statistical tests. The prototype design can be adapted in clinical settings.

# 2373743 Automated Lumen Diameter and Interadventitial Diameter Show a Relationship With Plaque Score on B-Mode Carotid Ultrasound

Tadashi Araki<sup>2</sup>, Krishna Kumar<sup>3</sup>, Nobutaka Ikeda<sup>4</sup>, Aditya Sharma<sup>5</sup>, Francesco Lavra<sup>6</sup>, Jeny Rajan<sup>3</sup>, Luca Saba<sup>6</sup>, Andrew Nicolaides<sup>7</sup>, John Laird<sup>8</sup>, Shoaib Shafique<sup>9</sup>, Jasjit Suri<sup>1\*</sup>

<sup>1</sup>Electrical Engineering, University of Idaho (Affiliate), Pocatello, ID, USA; <sup>2</sup>Electrical Engineering, AtheroPoint, LLC, Roseville, CA USA; <sup>3</sup>Division of Cardiovascular Medicine, Toho University Ohashi Medical Center, Tokyo, Japan; <sup>4</sup>Computer Science and Engineering, National Institute of Technology Karnataka, Mangalore, Karnataka, India; <sup>5</sup>Cardiovascular Medicine, National Center for Global Health and Medicine, Tokyo, Japan; <sup>6</sup>Division of Cardiovascular Medicine, University of Virginia, Charlottesville, VA USA; <sup>7</sup>Radiology, University of Cagliari, Cagliari, Italy; <sup>8</sup>Vascular Diagnostic Center, University of Cyprus, Nicosia, Cyprus; <sup>9</sup>UC Davis Vascular Center, University of California, Davis, CA USA; <sup>10</sup>CorVasc Vascular Laboratory, Indianapolis, IN USA

**Objectives:** The carotid lumen diameter (LD) and interadventitial diameter (IAD) can be noninvasively measured using B-mode ultrasound. The plaque score (PS) has been used for the quantification of plaques in the arteries and can be associated with stroke risk. The present study finds the correlation between LD/IAD and PS and is used for stroke risk stratification.

**Methods:** A total of 202 patients' left and right common carotid artery (404 carotid images) B-mode ultrasound images were retrospectively analyzed (ethics approval with Institutional Review Board was granted by Toho University) with mean age of 69 ± 15.9 years. Mean hemoglobin A1c, low-density lipoprotein, high-density lipoprotein, and cholesterol of patients were 6.28 ± 1.1, 101.27 ± 31.6, 50.26 ± 14.8, and 175.04 ± 38 mg/dL, respectively. **LD/IAD Measurement:** LD and IAD were measured automatically from B-mode ultrasound images using an advanced edge detection method. **Plaque Score Measurement:** The PS was computed by adding the maximal thickness in millimeters of plaques in each of the 4 segments from the internal carotid artery and common carotid artery. The correlation coefficients (CCs) between (a) LD and PS and (b) IAD and PS were calculated and compared.

**Results:** The CC observed between (a) LD and PS was 0.19 (*P* < .007), and between (b) IAD and PS, it was 0.25 (*P* < .0006). On excluding the outliers, a moderate to high CC was observed and between (a) LD and PS, at 0.38 (*P* < .0001), and between (b) IAD and PS, it was 0.25 (*P* < .0001). We validated our automated LD/IAD measurements against 2 manual expert tracers. The corresponding errors for LD were 0.27 ± 0.26 and 0.25 ± 0.24 mm, while for IAD, the errors were 0.23 ± 0.23 and 0.24 ± 0.24 mm (sensitivity, 100%; specificity, 100%). The intraobserver CCs between the 2 manual tracings for LD and between the 2 manual tracings for IAD were 0.95 (*P* < .0001) and 0.98 (*P* < .0001), respectively.

**Conclusions:** Carotid IAD is more strongly correlated to PS compared to carotid LD. Our system is fully automated, reliable, and validated.



### 2375021 Initial Attempt Combining Transthoracic Echocardiography and Ultrasonography to Diagnose Intravascular and Intracardiac Metastatic Tumors

Jiong Wang<sup>1,2</sup>, \* Yi Cheng<sup>2</sup>, Yueh Lee<sup>1</sup>, Ye Zheng<sup>2</sup>, Yongmei Wang<sup>3</sup>, Xiaobin Tang<sup>4</sup>, Chun Zhang<sup>5</sup>

<sup>1</sup>Radiology, University of North Carolina Hospital, Chapel Hill, NC USA; <sup>2</sup>Ultrasound, <sup>3</sup>Radiology, <sup>4</sup>Vascular Surgery, <sup>5</sup>Echocardiography, Beijing Anzhen Hospital, Beijing, China

**Objectives:** Ultrasonography (US) and transthoracic echocardiography (TTE) are seldom applied in the comprehensive evaluation of cardiovascular metastatic tumor thrombi in routine clinical practice. We attempt to combine US with TTE in the diagnosis of metastatic tumor thrombi in the heart and vessels.

**Methods:** Vascular, abdominal, pelvic, and small-parts US was applied in 18 patients and transthoracic echocardiography was conducted in 14 patients to evaluate metastatic tumor thrombi.

**Results:** The tumor thrombi invaded the inferior vena cava (IVC) system in 12 patients, superior vena cava (SVC) system in 5 patients, and aorta in 1 patient. The tumor thrombi extended to the right cardiac chamber in 11 patients; 6 patients had pathological diagnoses. The primary neoplasm was identified by conventional imaging in 8 patients, and 1 patient had no more information. The morphology and echogenicity of the tumor thrombi were diverse and depended on their original tumor; most had imaging characteristics of solid masses except for 2 leiomyomatosis cases with tube-like masses; the tumor thrombi were either continuous or distinct from the original tumors. The neoplastic vascularity in the thrombus was the primary characteristic distinguishing the lesion from a clot.

**Conclusions:** Combining US and TTE is a feasible way to identify the location and extension of metastatic tumor thrombi in most patients. The right ventricular inflow tract/right heart 2-chamber view is an important and useful view to differentiate cardiac tumor thrombi from the SVC with those from the IVC. Misdiagnosis can be avoided using this view in clinical practice.

### 2381935 Ultrasound Characterization of Carotid Plaque Vulnerability in Patients Prior to Endarterectomy

Huan Dong<sup>1,\*</sup>, Maria Stanczak<sup>1</sup>, John Farber<sup>2</sup>, Paul DiMuzio<sup>3</sup>, Priscilla Machado<sup>1</sup>, Laurence Needleman<sup>1</sup>, Flemming Forsberg<sup>1</sup>

<sup>1</sup>Radiology, <sup>2</sup>Pathology, <sup>3</sup>Vascular Surgery, Thomas Jefferson University Hospital, Philadelphia, PA USA

**Objectives:** To investigate 2 new ultrasound (US) image-processing techniques (MicroPure and SMI; Toshiba Medical Systems, Tokyo, Japan) for evaluating carotid plaque calcification and neovascularization as predictors of carotid plaque vulnerability.

**Methods:** Twelve subjects, with preoperative CT angiography (CTA) and scheduled for carotid endarterectomy, were enrolled in an ongoing Institutional Review Board–approved pilot study. Bilateral grayscale and power Doppler of the carotids were performed followed by MicroPure and SMI using an Aplio 500 US system (Toshiba). MicroPure combines nonlinear imaging and speckle suppression to mark suspected calcifications as white spots in a blue overlay, while SMI utilizes advanced clutter suppression to extract microvascular flow signals and depicts those as a color overlay or a monochrome flow map. Two independent reviewers scored calcifications as present or absent, while intraplaque neovascularity was scored on a 4-point scale (0–3; no flow to marked vaso vasorum flow). MicroPure and SMI assessments were compared to conventional US and CTA for the evaluation of intraplaque calcifications and neovascularity using Wilcoxon signed rank tests, with pathology as the reference standard. Inter-reader agreement was established by the  $\kappa$  statistic.

**Results:** One subject was eliminated from the study due to technical difficulties (ie, 22 carotids were studied). To date, 6 of the 12 subjects have undergone endarterectomy (producing 7 specimens due to 1 case of bilateral endarterectomies). Intraplaque neovascularization was detected by SMI in 6 of 7 specimens and overall in 17 of 22 vessels examined. There was excellent inter-reader agreement ( $\kappa = 0.74$ ) and no statistical differences between both readers and pathology ( $P > .08$ ). Intraplaque neovascularization was not detected by CTA. Intraplaque microcalcifications were detected in 6 of the 7 specimens by MicroPure but did not provide information not already evident with conventional US.

**Conclusions:** SMI may have potential for predicting key histopathologic features of vulnerable carotid plaques that are not well evaluated by conventional imaging modalities. MicroPure is designed for breast imaging and appears less useful in carotid applications.

### 2385100 Initial Assessment of Carotid Doppler Velocity Measurement Reproducibility in Normal Volunteers

Nicole Strissel<sup>1,\*</sup>, Leonardo de Souza<sup>2</sup>, Heather Hatz<sup>1</sup>, Crystal Koski<sup>1</sup>, Jeanie Otten<sup>1</sup>, Ryan Karshen<sup>1</sup>, Donald Tradup<sup>1</sup>, Zaiyang Long<sup>1</sup>, Nicholas Hangiandreou<sup>1</sup>, Thanila Macedo<sup>1</sup>

<sup>1</sup>Radiology, Mayo Clinic, Rochester, MN USA; <sup>2</sup>Masters in Surgery Program, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

**Objectives:** Knowledge of the standard deviation (SD) of clinical peak systolic velocity (PSV) measurements would greatly facilitate PSV comparisons between new and prior exams and with standard velocity threshold values. Reproducibility may vary between vascular ultrasound (US) practices due to differences in US imaging systems, clinical protocols, and levels of sonographer training and experience. Our aim was to measure PSV measurement SD in the carotid vessels in normal volunteers in our practice.

**Methods:** The right and left distal common carotid artery (CCA), bulb, and internal carotid artery (ICA) in 5 normal volunteers (2 male, 3 female) were scanned by 4 sonographers in separate scan sessions on 2 different days, using our standard clinical approach. Sonographer experience ranged from  $\approx 3$ –15+ years. Two nonsequential repeat measurements of each vessel segment were made by each sonographer in each scan session. PSV SDs and 95% confidence intervals were calculated using the method reported by Barnhart and Barboriak (*Transl Oncol* 2009; 2:231–235).

**Results:** SDs for the distal CCA, bulb, and ICA were 7.0, 7.1, and 9.6 cm/s, respectively. Overall SD was 8.0 cm/s (11.9% of the mean) for all vessel segments combined. SD ranged from 4.6–5.7 cm/s, across the 4 sonographers. These differences were not significant, but some evidence of bias was seen (tendency toward higher or lower measurements). SDs from measurements made earlier and later in each scan session were 7.3 and 6.1 cm/s, respectively, but this difference was not significant. Some correlation between measurement time in the scan session and sonographer was present due to lack of true randomization of sonographer scan order. No significant Doppler angle effect on SD was noted, but only a relatively narrow range of angles was used in this study. Overall SD was significantly reduced from 8.0 to 5.3 cm/s by averaging 2 measurements from different sonographers, while SD from same-sonographer averages was not significantly reduced.

**Conclusions:** The overall PSV SD was 8.0 cm/s in these normal subjects. Intersonographer performance was consistent despite differences in experience. Averaging pairs of different sonographer measurements reduced PSV SD by  $\approx 33\%$ .

### 2385287 Noninvasive Intracardiac Pressure Measurements Using Subharmonic Aided Pressure Estimation: Proof of Concept in Humans

**Sushmita Kulkarni<sup>1,2</sup>, Jaydev Dave<sup>1,\*</sup>, Purva Pangaonkar<sup>1,3</sup>, Maria Stanczak<sup>1</sup>, Maureen McDonald<sup>4</sup>, Ira Cohen<sup>5</sup>, Praveen Mehrotra<sup>5</sup>, Michael Savage<sup>5</sup>, Paul Walinsky<sup>5</sup>, Nicholas Ruggiero<sup>5</sup>, David Fischman<sup>5</sup>, Carolyn VanWhy<sup>5</sup>, Matthew Lombardi<sup>5</sup>, Flemming Forsberg<sup>1</sup>**

<sup>1</sup>Radiology, Thomas Jefferson University, Philadelphia, PA USA; <sup>2</sup>College of Engineering, <sup>3</sup>School of Biomedical Engineering, Science, and Health Systems, Drexel University, Philadelphia, PA USA; <sup>4</sup>School of Health Professions, <sup>5</sup>Cardiology, Thomas Jefferson University, Philadelphia, PA USA

**Objectives:** To evaluate the feasibility of noninvasive intracardiac pressure estimation using subharmonic signals from ultrasound (US) contrast agents in patients undergoing cardiac catheterization.

**Methods:** This Institutional Review Board–approved pilot study included 15 patients (age, 49–80 years; 13 male and 2 female) who were scheduled for left and right heart catheterization. All subjects provided written informed consent. Grayscale US imaging was performed for each patient before catheterization to mark optimum acoustic windows for cardiac imaging in a supine position. During the catheterization procedure, 2 vials of Definity (Lantheus Medical Imaging, North Billerica, MA) mixed in 50 mL of saline were infused intravenously at 4–10 mL/min to provide intracardiac contrast visibility. US scanning was performed with a Sonix RP (Analogic Corporation, Peabody, MA) scanner operating in pulse inversion mode with acoustic power values of 0, –2, and –4 dB at a transmit frequency of 2.5 MHz. Radiofrequency (RF) data were acquired for 10 seconds (n = 3 per power level) using a pulsed Doppler gate placed in the left and right ventricles (LV and RV) and the aorta (to provide a calibration factor) synchronously with pressure catheter measurements. Central pressures were also obtained using a SphygmoCor (AtCor Medical, Itasca, IL) device. Subharmonic signals were extracted from the RF data offline and filtered using MATLAB (Mathworks Inc, Natick, MA). Linear regression analysis was used to compare subharmonic aided pressure estimation (SHAPE) and pressure catheter data.

**Results:** SHAPE data were acquired from all 15 patients. The duration of contrast infusion ranged from 8–13 minutes. SHAPE data from 3 patients showed a relatively low subharmonic signal-to-noise ratio due to extrinsic factors and were eliminated from the study. Correlation between the SHAPE data and the pressure catheter data reached 0.4 and 0.7 for the LV and the RV, respectively. For data acquired with optimum acoustic power, error values as low as 2.6 mm Hg were obtained.

**Conclusions:** The SHAPE technique has potential to provide intracardiac pressures noninvasively, enabling more frequent pressure measurements for diagnosis or monitoring treatment outcome.

### Obstetric Ultrasound: Fetal Anomalies

*Moderator: Nazrin Benion, MD*

### 2385005 Evaluation of Neural Tube Defects in More Than 200 Cases of Early Pregnancy Loss: Sonographic Detection of Failure Area

**David Hartge<sup>\*</sup>, Michael Gembicki, Jan Weichert**  
Prenatal Medicine, University Hospital of Schleswig-Holstein, Luebeck, Germany

**Objectives:** Sonographic evaluation of neural tube defects in cases of missed abortions (MA) with special emphasis on localizing the area where closure failure occurred.

**Methods:** Prospective evaluation of transvaginal 2D and 3D ultrasound evaluation of cases of MA in a single tertiary center. Macroscopic pathologic reports were included in this study.

**Results:** In 315/340 cases of MA, at least 1 embryo or fetus was present. In 92/340 cases, image quality was not adequate, mostly due to short crown-rump length (CRL). Sufficient diagnostic quality was generally achievable when CRL exceeded 8 mm. Thirty-seven of 223 embryos/fetuses showed neural tube defects: 27/37 cephaloceles, 5/37 anencephalies, 3/37 spina bifidas, 1/37 caudal regression syndrome, and 1/37 iniencephaly. In 26/37 (20, 5, 0, 0, and 1), a defective closure site could be allocated to an area corresponding to types III, IV, and V, respectively (Nakatsu, 2000), which is a risk factor for early pregnancy loss in human embryos. Mean CRL at time of detection was 13 mm.

**Conclusions:** Transvaginal sonographic evaluation of neural tube defects in embryos/fetuses is feasible, with reliable verification of the origin of the specific defect. Neural tube defects have a high prevalence and were present in 10.9% of the cases. Evaluation of neural tube defects in cases of MA should be offered to every affected patient, as periconception maternal folic acid supplementation in the following pregnancy is mandatory.

### 2377086 Association Between Soft Markers and Abnormal Newborn Phenotype in Women 35 Years or Older With Negative Cell-Free DNA Testing

**Anna Palatnik<sup>1,\*</sup>, Anna Romanova<sup>2</sup>, Patrick Schneider<sup>3</sup>, Jeffrey Dungan<sup>1</sup>**

<sup>1</sup>Obstetrics and Gynecology, Northwestern University, Feinberg School of Medicine, Chicago, IL USA; <sup>2</sup>Northwestern University, Feinberg School of Medicine, Chicago, IL USA; <sup>3</sup>Obstetrics and Gynecology, University of Chicago, NorthShore University Health System, Evanston, IL USA

**Objectives:** Women 35 years or older at the time of delivery are at highest risk of having a child with Down syndrome, and in recent years, the cell-free DNA analysis was recommended as a screening option in that population. In this study, our aim was to evaluate the association between the presence of soft markers on second-trimester ultrasound and an abnormal newborn phenotype in women 35 years or older who had risk-reducing cell-free DNA.

**Methods:** This was a cohort study of 667 women 35 years or older who elected to undergo cell-free DNA screening for the indication of advanced maternal age and received negative results. All women underwent a routine anatomic survey between 18 and 22 weeks. Women with multifetal gestations or delivery at an outside hospital were excluded. Bivariable analyses were performed comparing women with and without the presence of soft markers (choroid plexus cyst, echogenic cardiac focus, pyelectasis, nuchal thickening, short humerus or femur, and echogenic bowel) on the anatomic survey. Multivariable logistic regression was performed to assess the independent association of soft markers with an abnormal newborn phenotype.

**Results:** Of 667 anatomic surveys, 58 demonstrated the presence of soft markers. In bivariable analysis, women with the presence of soft markers had a higher frequency of fetal structural anomalies detected on the anatomic survey (6.5% vs 1.6%;  $P = .02$ ). The rest of the characteristics, including maternal age, body mass index, race/ethnicity, prior pregnancy loss, and presence of maternal diabetes, were similar between the 2 groups. The frequency of an abnormal newborn phenotype was higher among women with the presence of soft markers (5.0% vs 1.1%;  $P = .04$ ). In multivariable analysis, after adjusting for the presence of structural anomalies, soft markers were not associated with an abnormal newborn phenotype (odds ratio, 0.72; 95% confidence interval, 0.04–11.74).

**Conclusions:** Among women who are 35 years or older with risk-reducing cell-free DNA, no association was found between the presence of soft markers on the anatomic survey and an abnormal newborn phenotype.

### 2377581 Congenital Lung Overinflation: A Rare, Enigmatic Lung Lesion on Detailed Fetal Sonography

Edward Oliver<sup>1</sup>, \* Suzanne Iyob<sup>1</sup>, Steven Horii<sup>1,2</sup>, Teresa Victoria<sup>1</sup>, Nahla Khalek<sup>1</sup>, N. Scott Adzick<sup>1</sup>, Lori Howell<sup>1</sup>, Beverly Coleman<sup>1</sup>

<sup>1</sup>Center for Fetal Diagnosis and Treatment, Children's Hospital of Philadelphia, Philadelphia, PA USA; <sup>2</sup>Radiology, Perelman School of Medicine, Hospital of the University of Pennsylvania, Philadelphia, PA USA

**Objectives:** To report the variable sonographic features in prenatal cases of suspected congenital cystic adenomatoid malformation (CCAM) or nonspecified lung lesions with a final surgical pathology or postnatal computed tomographic (CT) diagnosis of congenital lung overinflation (CLO).

**Methods:** An Institutional Review Board–approved database search of medical records was performed at the Center for Fetal Diagnosis and Treatment at Children's Hospital of Philadelphia for prenatally diagnosed lung lesions with a final diagnosis of CLO. All patients had detailed ultrasound (US) with gray scale and color Doppler and ultrafast magnetic resonance (MR) scans for comparison. Lesion location, size, echo texture, and vascularity were assessed on US.

**Results:** The study population consisted of 10 patients with a mean maternal age of 29.0 years and mean gestational age of 24 weeks 1 day. Lesion locations were 2 cases in the left upper lobe, 2 in the left lower lobe, 1 in the right upper lobe, 3 in the right lower lobe, and 2 in more than 1 lobe. Mean volume on US was 32.8 mL. Texture was homogeneously echogenic relative to normal lung in 100% with no visualized macrocysts, and color Doppler demonstrated only a pulmonary arterial supply and venous drainage in 90%, with a small feeding vessel questioned in 1 case. Hypervascularity was observed in 3 cases. Nonimmune hydrops was not seen in any case. Ascites, however, was observed in 2 cases, which was trace and large volume. CLO was the most likely diagnosis on US in 2 and included in the differential in 2, CCAM in 5, and CCAM, hybrid, or bronchopulmonary sequestration in 1. CLO was the most likely diagnosis on MR in 2, CCAM most likely in 7, and no specification other than “lung lesion” in 1. Five cases had pathology-proven CLO, and 5 had postnatal CT diagnosis of a hyperinflated lung confirming CLO.

**Conclusions:** CLO should be considered in the differential of in utero echogenic lung masses without macrocysts. Prevalence has been reported for the left upper lobe; however, our results indicate any lobe can be involved, and lesions may even be multifocal. Size is also quite variable; however, flow is consistently pulmonary in origin and may be hypervascular. Smaller lesions may be managed expectantly without surgery.

### 2378007 The Utility of Repeat Midtrimester Anatomy Ultrasound for Anomaly Detection

S. Lindsay Wood, \* John Owen, Sheri Jenkins, Lorie Harper  
Obstetrics and Gynecology, Division of Maternal-Fetal Medicine,  
University of Alabama at Birmingham, Birmingham, AL USA

**Objectives:** To assess the utility of repeat anatomy ultrasound (US) for anomaly detection following prior suboptimal US visualization (SUV).

**Methods:** Retrospective cohort of all singletons with a fetal anatomic US attempt before 20 weeks, delivered at a single institution from 2006–2014. US completion was based on criteria defined by the AIUM, SMFM, ACR, SRU, and ACOG. The presence or absence of major structural anomalies (causing death, significant disability, or requiring medical/surgical treatment) was confirmed for all prenatally detected anomalies, neonatal intensive care unit admissions, and neonatal deaths. Patients with an incomplete US underwent repeat US until completion. Groups were compared using a *t* test and  $\chi^2$  test as appropriate. The num-

ber of US examinations needed to detect 1 anomaly was assessed for each US performed.

**Results:** A total of 13,855 US examinations were performed, including 2326 detailed and 11529 standard US examinations. Overall, 341 anomalies were detected (2.5%). A total of 12,811 (92%) US examinations were completed on the first attempt at a mean gestational age (GA) of 18.5  $\pm$  weeks (first); 991 (7%) patients required 1 repeat US, completed at a mean GA of 20.2  $\pm$  weeks (second); 53 patients required  $\geq 2$  repeat US examinations (third). Groups significantly differed by maternal age, race, payor, body mass index, diabetes, and hypertension. The numbers of US examinations needed to detect 1 anomaly were 48, 216, and 1155 for first, second, and third, respectively. The majority (77.7% [265]) of anomalies were detected in first, 18.8% (64) in second, and 3.5% (12) in third. Most anomalies detected on repeat US were detected in anatomic areas with SUV on prior US (Table 1).

**Conclusions:** Most major anomalies are detected on initial US, even if incomplete. The residual risk of an anomaly following SUV is low, suggesting repeat US may be an inappropriate utilization of resources. Anomalies detected following incomplete US were mostly congruent with the SUV system, which may add to patient counseling following incomplete US.

Table 1

Anomaly Type	Congruent SUV System	Incongruent SUV System	<i>P</i> <sup>a</sup>
Head/face/spine	17	2	
Chest/heart	9	8	
Abdomen/genitourinary/ gastrointestinal	15	24	.002
Extremities	0	1	
All anomaly types	41	35	

<sup>a</sup> $\chi^2$ .

### 2380242 Cardiac Axis in Fetuses With Tetralogy of Fallot: Associations With Prenatal Findings, Genetic Anomalies, and Postnatal Outcome

Yili Zhao<sup>1</sup>, \* Scott Edington<sup>2</sup>, Elena Sinkovskaya<sup>1</sup>, Jonathan Fleenor<sup>2</sup>, Alfred Abuhamad<sup>1</sup>

<sup>1</sup>Maternal-Fetal Medicine, Eastern Virginia Medical School, Norfolk, VA USA; <sup>2</sup>Children's Hospital of the King's Daughters, Norfolk, VA USA

**Objectives:** To compare the prenatal findings, associated genetic anomalies, and postnatal outcome of fetal tetralogy of Fallot (TOF) with or without an abnormal cardiac axis (CAx).

**Methods:** Of all pregnancies scanned by obstetric ultrasound in our clinic between 2005 and 2014, 85 cases were diagnosed with TOF. Follow-up ultrasound and postnatal outcome was available on 67 cases. Of those, 60 cases were confirmed with TOF postnatally and contributed to the study population. The remaining 7 cases had other cardiac abnormalities and were not included in this study. The study population (60 cases) was divided into 2 groups with normal CAx (33/60) and abnormal CAx (27/60). Prenatal sonographic findings, associated genetic anomalies, and postnatal outcome were compared between the 2 groups.

**Results:** Compared to TOF fetuses with normal CAx, those with abnormal CAx were more likely to be complicated with pulmonary atresia (16/27 vs 5/33; *P* = .026), as well as a right-sided aortic arch (13/27 vs 7/33; *P* = .028). Postnatal death happened in 30.4% (7/23) of patients with abnormal CAx but only in 6.5% (2/31) of patients with normal CAx (*P* = .028). The incidence of genetic anomalies was similar between fetuses with and without abnormal CAx.



**Conclusions:** In fetuses with TOF, abnormal CAX is associated with pulmonary atresia, a right aortic arch, and a higher chance of postnatal death.

### 2385879 Lung-to-Head Ratio, Ultrasound Liver-to-Thoracic Ratio, and Stomach Position in Fetuses With Isolated Left-Sided Congenital Diaphragmatic Hernia: Proposal of Multiple-Parameter Sonographic Evaluation

Rodrigo Ruano<sup>1</sup>, \*Nicolas Sananes<sup>1</sup>, Ingrid Britto<sup>1</sup>, Oluayinka Olutoye<sup>2</sup>, Darrell Cass<sup>2</sup>, Michael Belfort<sup>1</sup>, Wesley Lee<sup>1</sup>

<sup>1</sup>Obstetrics and Gynecology; <sup>2</sup>Pediatric Surgery; Baylor College of Medicine, Houston, TX USA

**Objectives:** To evaluate the accuracy in predicting postnatal outcome in fetuses with isolated left-sided congenital diaphragmatic hernia (CDH) using multiple sonographic parameters.

**Methods:** Using the same ultrasound image (cross-sectional view of the fetal chest at the level of the 4-chamber view of the heart), the following ultrasound parameters were evaluated in 77 fetuses with left-sided CDH: fetal lung size by measuring the lung-to-head ratio (LHR) and liver herniation by assessing the ultrasound liver herniation-to-thoracic area ratio (US-LiTR) and the stomach position (SP). The predictive value of ultrasound parameters for mortality and the need for extracorporeal membrane oxygenation was evaluated by univariate, multivariate, and factor analysis and by receiver operating characteristic curves.

**Results:** The LHR, US-LiTR, and SP (according to Cordier classifications) were significantly associated with both mortality (area under the curve [AUC], 0.86; 95% confidence interval [CI] 0.74–0.98; AUC, 0.77; 95% CI, 0.63–0.90; and AUC, 0.74; 95% CI, 0.62–0.87). Significant correlations were observed between all these ultrasound parameters. The combination of LHR with the US-LiTR and with SP statistically improved the prediction of mortality (AUC, 0.86; 95% CI, 0.74–0.98; and AUC, 0.83; 95% CI, 0.74–0.92, respectively).

**Conclusions:** It is possible to evaluate the LHR, US-LiTR, and the SP by conventional sonography. The combinations of those ultrasound measurements seem to improve the accuracy of predicting mortality in those fetuses.

### 2386805 What Is the Role of 11- to 14-Week Ultrasound in Women With Negative Noninvasive Prenatal Screening?

Emily Reiff<sup>1,2</sup>, Sarah Little<sup>1</sup>, Lori Dobson<sup>1</sup>, Louise Wilkins-Haug<sup>1</sup>, Bryann Bromley<sup>1,2,3\*</sup>

<sup>1</sup>Obstetrics and Gynecology, Brigham and Women's Hospital, Boston, MA USA; <sup>2</sup>Obstetrics and Gynecology, Massachusetts General Hospital, Boston, MA USA; <sup>3</sup>Diagnostic Ultrasound Associates, Brookline, MA USA

**Objectives:** Examine the role of 11- to 14-week ultrasound in women with negative noninvasive prenatal screening (NIPS).

**Methods:** We conducted a retrospective cohort study of pregnant women with negative NIPS screening results between March 2012 and March 2014 who received their complete obstetric care by providers at 2 tertiary care centers and underwent an 11- to 14-week ultrasound examination. Patients were included in the study if they were candidates for NIPS based on (1) maternal age of 35 years or older at delivery and (2) history of prior pregnancy with a trisomy. Twin pregnancies were included in the study. Patients in whom the only indication for NIPS was an abnormal ultrasound finding were excluded. The timing of NIPS and the commercial company performing the analysis were at the discretion of the primary provider. Ultrasound imaging included a crown-rump length and nuchal translucency (NT) measurement, and the anatomic evaluation met the AIUM recommendations of “embryonic/fetal anatomy appropriate for the first trimester” and included the body contour, cranial shape, umbilical cord insertion site, and extremities. Early imaging findings were compared to obstetric outcomes by medical record review.

**Results:** A negative NIPS and 11- to 14-week ultrasound were available in 1739 patients. An unexpected finding was identified in 60/1739 (3.5%) patients. Previously unrecognized twins occurred in 13 patients (0.7% of scans), and an unsuspected fetal demise was identified in 10 patients (0.6%). Thirty-seven (2.1%) patients with a living fetus were identified as having abnormal sonographic findings; 33 fetuses had an NT  $\geq 3.0$  mm, including 4 with “isolated” cystic hygroma and 3 with concurrent structural abnormality. Four fetuses had a major structural abnormality without a thickened NT. Karyotype confirmed euploidy in 98.7% of available cases. In 1 patient with an abnormal nuchal translucency and multiple structural anomalies, karyotype revealed trisomy 18, representing a false-negative cell-free DNA screen. Pregnancy termination was chosen by 63.6% of those with cystic hygroma or a structural anomaly at the 11- to 14-week scan.

**Conclusions:** Unexpected findings at the 11- to 14-week scan occur in 3.5% of patients with negative NIPS. Recognition provides options for comprehensive testing, consultation, and management.

### 2386862 Patient Choice and Clinical Outcomes Following Positive Noninvasive Prenatal Screening

Lori Dobson<sup>2</sup>, Emily Reiff<sup>1,2</sup>, Sarah Little<sup>2</sup>, Louise Wilkins-Haug<sup>2</sup>, Bryann Bromley<sup>1,2,3\*</sup>

<sup>1</sup>Obstetrics and Gynecology, Massachusetts General Hospital, Boston, MA USA; <sup>2</sup>Obstetrics and Gynecology, Brigham and Women's Hospital, Boston, MA USA; <sup>3</sup>Diagnostic Ultrasound Associates, Boston, MA USA

**Objectives:** Evaluate the role of the 11- to 14-week scan in patients with positive noninvasive prenatal testing (NIPS) and the impact on patient choice and clinical outcome.

**Methods:** Retrospective cohort study of women with positive NIPS receiving obstetric care from providers affiliated with 2 academic centers between March 2012 and December 2014. Patients were screened based on ACOG indications. The timing of NIPS was at the discretion of the primary provider. Patients undergoing an 11- to 14-week scan for aneuploidy evaluation had a crown-rump length and nuchal translucency measurement. Early anatomic imaging met the AIUM recommendations of “embryonic/fetal anatomy appropriate for the first trimester” and included at minimum evaluation of body contour, cranium, umbilical cord insertion site, and extremities. Sonographic assessment of the fetus at  $\geq 15$  weeks was performed based on referral by the obstetric provider and included a fetal anatomic evaluation that was as complete as possible. Medical records were reviewed for genetic counseling, sonographic findings, diagnostic testing, karyotype, and pregnancy outcome.

**Results:** NIPS was positive in 114 women: 105 singletons and 9 twin pairs. NIPS was positive for autosomal trisomy (21, 18, and 13) in 96 (84.2%) and sex chromosome aneuploidy in 18 (15.8%). Certified genetic counselors provided posttest counseling in 95% of patients. Karyotype was available in 91/105 (86.7%) singletons and confirmed aneuploidy in 75/91 (82.4%). Discordance was identified in 16/91 (17.6%). An abnormal sonographic finding was present in 58/75 (77.3%) with concordance vs 4/16 (25%) with discordance. The positive predictive value (PPV) of NIPS with any sonographic finding was 93.6% vs 58.6% without a finding. Pregnancy termination was chosen in 53/79 (67%) with an abnormal or unknown karyotype for autosomal trisomy. Nine patients (16.7%) terminated without prenatal confirmation of karyotype. In those choosing to terminate, 55% were able to do so at  $\leq 14$  weeks.

**Conclusions:** NIPS discordance with karyotype reinforces the need for karyotype confirmation. Sonographic findings modify the PPV of NIPS. Termination rates are not higher than historical controls; however, 16.7% of patients terminated without prenatal confirmation of karyotype despite counseling.



### 2392543 Are Nuchal Septations Clinically Significant for Early Prenatal Genetic Screening?

**Lauren Mack<sup>1</sup>,\* Wesley Lee<sup>1</sup>, Arame Thiam<sup>2</sup>, Joan Mastrobattista<sup>1</sup>, Michael Belfort<sup>1</sup>, Alireza Shamshirsaz<sup>1</sup>, Rodrigo Ruano<sup>1</sup>, David Rendon<sup>1</sup>, Jimmy Espinoza<sup>1</sup>**

<sup>1</sup>Obstetric and Gynecologic Ultrasound, Baylor College of Medicine, Houston, TX USA; <sup>2</sup>Baylor College of Medicine, Houston, TX USA

**Objectives:** Prior reports of transvaginal ultrasonography during early pregnancy have suggested that visualization of septated cystic hygromas are associated with a higher incidence of abnormal karyotype and a poorer fetal prognosis. This study investigates whether the presence of septations in the nuchal translucency (NT) during transabdominal scanning is an independent predictor of abnormal karyotype.

**Methods:** A retrospective cohort of all first-trimester screens was evaluated at a single tertiary center from 2011 to 2014. Women who did not have follow-up at our institution were excluded. An assessment was performed by 1 expert reviewer of all cases with an increased NT to confirm whether or not nuchal septations were visualized from ultrasound screening. Logistic regression models were used to estimate the odds ratio (OR) of an abnormal karyotype associated with the presence of nuchal septations, adjusting for potential confounders, including NT measurement, advanced maternal age ( $\leq 35$  years), race/ethnicity, parity, and multiple gestation.

**Results:** This cohort included 2779 consecutive patients, of whom 0.5% had a confirmed chromosomal abnormality. Nuchal septations were visualized in 0.5% (15) and an increased NT in 1.7% (46) of the population sample. Both the presence of septations and an increased NT were independently associated with an abnormal karyotype (OR, 7.1; 95% confidence interval [CI], 1.2–45.0; and OR, 3.7; 95% CI, 2.5–5.7, respectively). Abnormal karyotypes included trisomy 21, 18, 13 and Noonan's.

**Conclusions:** Visualization of nuchal septations during the first-trimester screen is an independent risk factor for an abnormal karyotype. The presence of nuchal septations in addition to NT measurement should be documented and incorporated into prenatal counseling for aneuploidy.

### 2392630 Are Ultrasonographic Renal Parameters Associated With Urinary Biochemistry in Fetuses With Lower Urinary Tract Obstruction?

**Ahmed Nassr<sup>1</sup>,\* Chester Koh<sup>2</sup>, Patricio Gargollo<sup>2</sup>, Alireza Shamshirsaz<sup>1</sup>, Jimmy Espinoza<sup>1</sup>, Haleh Sangi-Haghpeykar<sup>1</sup>, Stehen Welty<sup>2</sup>, David Roth<sup>2</sup>, Michael Belfort<sup>1</sup>, Michael Braun<sup>2</sup>, Rodrigo Ruano<sup>1</sup>**

<sup>1</sup>Obstetrics and Gynecology, Baylor College of Medicine, Houston, TX USA; <sup>2</sup>Baylor College of Medicine, Houston, TX USA

**Objectives:** To evaluate the association between ultrasonographic renal parameters and urine biochemistry in fetuses with lower urinary tract obstruction (LUTO).

**Methods:** Data were collected prospectively from 31 consecutive fetuses with LUTO that underwent vesicocentesis for fetal urinary biochemistry between April 2013 and September 2015. The following ultrasonographic findings related to fetal kidneys were evaluated immediately before the vesicocentesis: renal echogenicity, presence of cortical cysts, presence of images suggestive of “renal dysplasia” (hyperechoic cystic kidneys with no cortical-medullary differentiation), and severe oligohydramnios (amniotic fluid <5th percentile). These ultrasonographic parameters were compared to the fetal urinary concentration of sodium, chloride, calcium, osmolality, and  $\beta_2$ -microglobulin. Logistic regression was performed to evaluate the association between ultrasonographic renal parameters and fetal urinary biochemical markers. A statistical difference was considered when  $P < .05$ .

**Results:** There was no statistical association between any ultrasonographic fetal renal parameters and fetal urinary biochemistry (Table 1).

**Conclusions:** Our data suggest that fetal renal parameters and urinary biochemistry are not statistically associated in cases with LUTO. Further studies are necessary to confirm our findings and to investigate the use of those factors to predict postnatal renal function in combination.

Table 1. Association Between Ultrasound Renal Parameters and Fetal Urinary Biochemistry

Ultrasound Parameter	Fetal Urinary Biochemistry	OR (95% CI)	P
Hyperechoic kidneys	Sodium	1.03 (0.99–1.07)	.14
	Chloride	1.04 (0.99–1.10)	.13
	Calcium	1.35 (0.92–2.17)	.16
	Osmolarity	1.0 (0.98–1.02)	.92
	$\beta_2$ -Microglobulin	1.0 (1.0–1.001)	.23
Renal cysts	Sodium	1.05 (0.99–1.13)	.15
	Chloride	1.09 (1.0–1.24)	.11
	Calcium	1.06 (0.72–1.59)	.75
	Osmolarity	1.02 (0.99–1.06)	.25
	$\beta_2$ -Microglobulin	1.0 (1.0–1.001)	.13
Renal dysplasia	Sodium	1.06 (0.99–1.17)	.19
	Chloride	1.16 (1.00–1.50)	.13
	Calcium	0.98 (0.59–1.59)	.93
	Osmolarity	1.03 (0.99–1.09)	.23
	$\beta_2$ -Microglobulin	1.00 (1.0–1.01)	.47
Bilateral hydronephrosis	Sodium	0.99 (0.96–1.03)	.74
	Chloride	0.99 (0.94–1.04)	.60
	Calcium	0.74 (0.45–1.10)	.18
	Osmolarity	0.99 (0.97–1.02)	.67
	$\beta_2$ -Microglobulin	1.0 (0.99–1.00)	.23
Oligohydramnios	Sodium	1.01 (0.96–1.06)	.74
	Chloride	1.05 (0.98–1.14)	.15
	Calcium	1.32 (0.85–2.31)	.26
	Osmolarity	1.01 (0.98–1.04)	.54
	$\beta_2$ -Microglobulin	1.00 (1.00–1.001)	.41

CI indicates confidence interval; and OR, odds ratio.

### 2393058 Progression of Functional Motor Level in Neonates With Myelomeningocele Can Be Scored by Prenatal Sonography

**Joan Mastrobattista<sup>1</sup>,\* Elena Carreras<sup>2</sup>, Lauren Mack<sup>1</sup>, Anna Maroto<sup>2</sup>, William Whitehead<sup>3</sup>, Tamara Illescas<sup>2</sup>, Karin Fox<sup>1</sup>, Carlota Rodo<sup>2</sup>, Michael Belfort<sup>1</sup>, Silvia Arevalo<sup>2</sup>, Rodrigo Ruano<sup>1</sup>, Rajshi Gandhi<sup>1</sup>, Wesley Lee<sup>1</sup>, Ampar Cuxart<sup>4</sup>**

<sup>1</sup>Obstetric and Gynecologic Ultrasound, <sup>2</sup>Pediatric Neurosurgery, Baylor College of Medicine, Houston, TX USA; <sup>3</sup>Maternal-Fetal Medicine, <sup>4</sup>Physical Medicine and Rehabilitation, Hospital Universitari Vall d'Hebron, Barcelona, Spain

**Objectives:** Currently there are no reliable prenatal sonographic predictors of preintervention and postintervention neurologic function in fetuses affected by myelomeningocele (MMC). To remedy this gap, we developed a sonographic prediction tool and tested it in a prospective cohort. The primary study outcome was performance of a sonographic evaluative tool (SET) in accurately and precisely predicting the site and functional level of neurologic deficits in infants with MMC. The secondary outcome was to determine the rate and extent of deterioration over the course of gestation using the same sonographic measures: specifically, testing if SET predicted the level of fetal neurologic function throughout pregnancy.

**Methods:** A prospective cohort study of fetuses with MMC between July 2010 and July 2015 was conducted. Patients underwent in utero MMC repair or continued pregnancy without a repair based on clin-

ical eligibility (MOMs trial) and patient preference. Motor function of the lower extremities was studied using a novel technique first described by Carreras et al: (1) prenatally, standardized sonographic evaluation using intrauterine fetal limb movements to predict the functional level based on the known nerve distribution, performed every 3–6 weeks from enrollment to delivery; and (2) postnatally, clinical motor evaluation (physical exam by a single examiner, blinded to sonographic results). Postnatal examination was used to confirm the side, site, and functional level.

**Results:** Twenty-six women were enrolled; 19 had in utero repair (17 fetoscopic, 2 open), and 7 continued without repair, initial sonographic evaluations at mean gestational ages of 24 and 29 weeks, respectively. Nine women in the repair and 3 women in the unrepaired group delivered <37 weeks. The prenatally assigned functional motor level in the repair group was on average 2–3 levels better than expected from the anatomic level. In the repair group, 2/19 cases showed a better functional level, and 2 exhibited a decreased functional level compared to the anatomic level. In the unrepaired group, 1/7 cases showed a better functional level, and 2 worsened throughout pregnancy, confirmed postnatally.

**Conclusions:** Sonographic evaluation appears to be a reliable method of monitoring neurologic function in fetuses with MMC, and in utero repair may prevent the progression of neurologic injury.

### 2393074 Prenatal Ultrasonography Reliably Predicts Postnatal Neurologic Function in Fetuses With Myelomeningocele

**Joan Mastrobattista<sup>1</sup>, Elena Carreras<sup>2</sup>, Lauren Mack<sup>1,\*</sup>, Anna Maroto<sup>2</sup>, William Whitehead<sup>3</sup>, Tamara Illescas<sup>2</sup>, Karin Fox<sup>1</sup>, Carlota Rodo<sup>2</sup>, Michael Belfort<sup>1</sup>, Silvia Arevalo<sup>2</sup>, Rodrigo Ruano<sup>1</sup>, Rajshi Gandhi<sup>1</sup>, Wesley Lee<sup>1</sup>, Ampar Cuxart<sup>1</sup>**

<sup>1</sup>Obstetric and Gynecologic Ultrasound, <sup>2</sup>Pediatric Neurosurgery, Baylor College of Medicine, Houston, TX USA; <sup>3</sup>Maternal-Fetal Medicine, <sup>4</sup>Physical Medicine and Rehabilitation, Hospital Universitari Vall d'Hebron, Barcelona, Spain

**Objectives:** There are currently no reliable prenatal predictors of neurologic function in fetuses affected by myelomeningocele (MMC). The study goals were to utilize a prospective, single-arm interventional cohort of MMC-affected fetuses to test a novel sonographic prediction tool in identifying subsequent neurologic function. We sought to determine if the prenatal functional level is different between the right and left lower extremities (LEs) in MMC. The primary objective was to determine if sonographic assessment of the functional level correlates with the postnatal motor level. A secondary objective was to investigate if differences in right and left LE function can be detected.

**Methods:** Prospective cohort study of fetuses with MMC. Patients underwent in utero MMC repair (fetoscopic/open) or continued pregnancy without a repair based on clinical eligibility (MOMs trial) and patient preference. All patients with fetal MMC identified between January 2013 and July 2015 were eligible. Motor function of the LEs was studied using a novel technique as first described by Carreras et al: (1) prenatally, standardized sonographic evaluation using intrauterine fetal limb movements to predict the functional level based on the known nerve distribution, performed every 3–6 weeks from enrollment to delivery; and (2) postnatally, clinical motor evaluation (physical exam by a single neurosurgeon or physical medicine and rehabilitation specialist, blinded to sonographic results). Postnatal examination was used to confirm the functional level determined by prenatal sonography.

**Results:** Twenty-three women were enrolled; 19 underwent in utero repair (17 fetoscopic, 2 open repair), and 4 were unrepaired. All patients delivered in our centers. Of these, 2 neonates in the in utero repair group and 1 neonate in the unrepaired group displayed functional differences between their right and left LEs as confirmed by postnatal evaluation. The state of symmetry or asymmetry between the right and the left LEs was correctly predicted by prenatal sonography in 18/23 (78%) cases.

**Conclusions:** Functional symmetry in the right and left LEs in fetuses with MMC can be predicted with a high degree of reliability by prenatal sonography.

## Point-of-Care Ultrasound

**Moderator: Kathleen Cross, RDMS, RT(R)(M)(CT)**

### 2365878 Interobserver and Intraobserver Agreement of Emergency Physicians and Cardiologists in the Echocardiographic Identification of Right Ventricular Dysfunction In Patients With Submassive Pulmonary Embolism

**Laura Oh<sup>1,\*</sup>, Angela Johnson<sup>1</sup>, Gregory Thacker<sup>1</sup>, Geoffrey Rose<sup>2</sup>, Thomas Johnson<sup>2</sup>, Michael Runyon<sup>1</sup>, Megan Templin<sup>1</sup>, James Norton<sup>3</sup>, Anthony Weekes<sup>1</sup>**

<sup>1</sup>Emergency Medicine, <sup>2</sup>Cardiology, <sup>3</sup>Biostatistics, Carolinas Medical Center, Charlotte, NC USA

**Objectives:** To prospectively determine interobserver and intraobserver agreement in the qualitative assessment of right ventricular dysfunction (RVD) with goal-directed echocardiography (GDE).

**Methods:** Two emergency medicine residents and 2 cardiologists reviewed 31 GDE video clips of normotensive patients with confirmed pulmonary embolism (PE). Nine GDE clips were repeated to assess for intraobserver agreement. Raters assessed clips for severe RV enlargement (RVE; RV: LV basal diameter ratio  $\geq 1.0$  and blunting of the apex of the RV on  $\geq 2$  different windows), RV systolic dysfunction (movement of tricuspid annulus toward the apex  $< 10$  mm and RV free-wall hypokinesis), and septal deviation.

**Results:** *Severe RVE:* Emergency physicians (EPs) had an observed agreement of 90.3% and a  $\kappa$  of 0.80 (95% confidence interval [CI], 0.58–1.0). Cardiologists had an observed agreement of 93.5% and a  $\kappa$  of 0.80 (95% CI, 0.70–1.0). *Severe RV Systolic Dysfunction:* EPs had an observed agreement of 90.3% and a  $\kappa$  of 0.76 (95% CI, 0.50–1.0). Cardiologists had an observed agreement of 90.3% and a  $\kappa$  of 0.80 (95% CI, 0.59–1.0). *Septal Deviation:* EPs had an observed agreement of 90.3% and a  $\kappa$  of 0.77 (95% CI, 0.53–1.0). Cardiologists had an observed agreement of 83.9% and a  $\kappa$  of 0.58 (95% CI, 0.27–0.88). Among the 4 participants, there was 84% agreement on the presence or absence of RVE ( $\kappa = 0.80$ ), 74.2% agreement for the presence or absence of RV systolic dysfunction ( $\kappa = 0.69$ ), and 71% agreement for the presence or absence of septal deviation ( $\kappa = 0.60$ ). Intraobserver agreement was 100% for each RVD variable for each observer ( $\kappa = 1.0$ ).

**Conclusions:** The agreement between EPs was substantial for RVE, RV systolic dysfunction, and septal deviation. The agreement between cardiologists was considered near perfect for RVE and RV systolic dysfunction and moderate for septal deviation. Agreement among 4 participants was substantial for both severe RVE and RV systolic dysfunction and “moderate” for septal deviation. RVD assessment with GDE is reproducible for risk stratification in PE.

### 2379399 Variable Interpretation of Cardiac Standstill Among Physician Sonographers

**Kevin Hu<sup>\*</sup>, Nachi Gupta, Felipe Merino, Phillip Andrus**

Emergency Medicine, Icahn School of Medicine at Mount Sinai, New York, NY USA

**Objectives:** Point-of-care echocardiography has been widely studied as a marker of prognosis in cardiac arrest (Blaivas, 2001; Tayal, 2003; Salen, 2005). Studies have shown widely varying results from 45% survivors of cardiac standstill to none (Tomruk, 2012; Blyth, 2012). Importantly, the very definition of standstill varies in these studies from a slight change in echogenicity of the myocardium to any kinetic cardiac activity. We hypothesized that the variability in research definitions of standstill would be reflected in those of individual sonographers. The goal of this study was to assess the variability in determination of standstill on bedside echocardiography among physician sonographers from different specialties and with various ultrasound experience.

**Methods:** We surveyed physician sonographers at 5 conferences held at 3 academic medical centers in the New York City area. They were allotted 20 seconds per slide to determine whether each of 15 video clips of patients in cardiac arrest were standstill or not. Data were collected anonymously using Turning Technologies' Turning Point polling software and exported to R for analysis.

**Results:** There were 98 total participants, including faculty, fellows, and resident physicians specializing in emergency medicine, critical care, and cardiology. There was only moderate inter-rater agreement among all participants (Krippendorff's  $\alpha$  coefficient = 0.47). This lack of agreement persisted across specialties, training levels, and self-reported ultrasound expertise (Table 1).

**Conclusions:** There is substantial variability in determination of cardiac standstill among physician sonographers of varied specialties and levels of training. A clear definition of cardiac standstill is necessary to improve the quality of cardiac arrest ultrasound research and to standardize the use of this technology at the bedside.

Table 1. Cardiac Standstill Inter-Rater Agreement

	$\alpha^a$	Agreement
Specialty: Emergency Medicine	0.50	Moderate
Specialty: Critical Care	0.40	Fair
Specialty: Cardiology	0.47	Moderate
Training Level: Attending	0.46	Moderate
Training Level: Fellow	0.55	Moderate
Training Level: Resident	0.43	Moderate
Ultrasound Experience: Basic	0.43	Moderate
Ultrasound Experience: Intermediate	0.53	Moderate
Ultrasound Experience: Expert	0.41	Moderate

<sup>a</sup>Krippendorff's  $\alpha$  coefficient: <.20, poor; 0.21–0.40, fair; 0.41–0.60, moderate; 0.61–0.80, good; 0.81–1.00, very good.

### 2379957 Emergency Physician Focused Cardiac Ultrasound Exam Improves Diagnosis of Ascending Aortic Dissection

Joseph Pare<sup>1,\*</sup>, Rachel Liu<sup>1</sup>, Christopher L. Moore<sup>1</sup>, Tyler Sherban<sup>2</sup>, Michael Kelleher<sup>3</sup>, Sheeja Thomas<sup>1</sup>, Richard Taylor<sup>1</sup>

<sup>1</sup>Emergency Medicine, Yale University, New Haven, CT USA;

<sup>2</sup>Frank H. Netter, MD, School of Medicine, North Haven, CT USA;

<sup>3</sup>Radiology, Yale New Haven Hospital, New Haven, CT USA

**Objectives:** Ascending aortic dissection (AAD) is an uncommon, time-sensitive, and deadly diagnosis with a nonspecific presentation. AAD is associated with aortic dilation, which can be determined by emergency physician focused cardiac ultrasound (EP FOCUS). The study objective was to determine if patients who receive EP FOCUS have at least a 1-hour reduced time to diagnosis for AAD in comparison to patients who do not receive EP FOCUS. Secondary outcomes were to determine if EP FOCUS reduced misdiagnosis, time to disposition, and mortality.

**Methods:** We performed a retrospective cohort analysis of patients treated at 1 of 3 affiliated emergency departments (EDs) from March 1, 2013, to May 1, 2015, with AAD. All autopsies were reviewed for missed cases. Patients were divided into 2 cohorts, EP FOCUS and non-EP FOCUS, to assess primary and secondary outcome measures. Study outcome measures, patient demographics, medical histories, presenting clinical findings, chest radiographic findings, and electrocardiographic findings were abstracted and compared between cohort groups. Student *t* tests, Fisher exact tests, and Wilcoxon rank sum tests were performed as appropriate for comparison between cohort groups.

**Results:** Of 386,547 ED visits, targeted review of 123 charts and 194 autopsy reports identified 32 patients for inclusion. Sixteen patients received EP FOCUS, and 16 did not. Median time to diagnosis in the EP FOCUS group was 80 (interquartile range [IQR], 46–157) minutes vs 226 (IQR, 109–1449) minutes in the non-EP FOCUS group ( $P = .023$ ). Misdiagnosis was 0% (0/16) in the EP FOCUS group vs 43.8% (7/16) for non-EP FOCUS ( $P = .028$ ). Mortality, adjusted for do not resuscitate, for EP FOCUS vs non-EP FOCUS was 15.4% vs 37.5% ( $P = .24$ ). The median EP FOCUS rooming time to disposition was 134 (IQR, 101–195) minutes vs non-EP FOCUS of 205 (IQR, 114–342) minutes ( $P = .27$ ). There was otherwise no statistical difference between abstracted information between cohort groups with the exception of heart rate of  $71 \pm 15$  beats per minute for EP FOCUS vs  $86 \pm 20$  beats per minute for non-EP FOCUS ( $P = .03$ ).

**Conclusions:** Patients who receive EP FOCUS are diagnosed faster and misdiagnosed less than patients who do not receive EP FOCUS. We recommend that assessment of the thoracic aorta be performed routinely during cardiac ultrasound in the ED.

### 2385154 Does Carotid Intima-Media Thickening Predict a Negative Stress Test in Low-Risk Chest Pain?

Matthew Tabbat

Emergency Department, MetroHealth Medical Center, Cleveland, OH USA; Case Western Reserve University School of Medicine, Cleveland, OH USA

**Objectives:** Chest pain is a common presentation to the emergency department (ED). Patients frequently undergo stress testing following negative diagnostic markers. Carotid intima-media thickness (CIMT) is a useful tool to noninvasively identify patients with a higher atherosclerotic burden. CIMT has been shown to be associated with myocardial infarction, stroke, coronary artery disease (CAD), as well as angiographic evidence of CAD. There are no known studies evaluating the use of CIMT on low-risk chest pain patients in the ED observation (OU) setting. The goal of this study is to evaluate CIMT in the ED OU to determine if it can be used as a tool to help predict patients who will have a negative stress test in attempt to risk stratify patients complaining of chest pain.

**Methods:** This is an ongoing prospective convenience sample of patients admitted to our ED OU with chest pain, dyspnea, or symptoms determined to be a coronary equivalent by the treating physician in the ED. Patients were included if they were to receive a stress test during their observation stay or had received one within 2 months prior to the ED OU visit. Patients were scanned with a high-frequency linear transducer in the long axis to the carotid artery. Three measurements of the IMT were taken on each side proximal to the carotid bulb within 1 cm of the bulb. The results were averaged on each side. The results were compared to a known standard for age and ethnicity at the 75th percentile. IMT above the 75th percentile for age and ethnicity on either side was considered a positive result.

**Results:** To date, 59 patients were evaluated; 5 had a positive stress test (8.8%; 0.95 confidence interval [CI], 1.4%–16.2%). Of the 57 patients, 37 patients (64.9%; 0.95 CI, 52.5%–77.3%) had a negative IMT study, and 20 (35.1.2%; 0.95 CI, 22.7%–47.5%) had a positive IMT study. There were 4 patients among the positive stress group who had a positive IMT (80%; 0.95 CI, 44.9%–100%) and 1 patient with a negative IMT (20%; 0.95 CI, 0%–55.1%).

**Conclusions:** In this cohort of patients with low-risk chest pain was a trend toward negative stress correlating with negative IMT. However, data are insufficient to confidently risk stratify patients based on IMT alone.



**2383172 Determining the Number of Ultrasound Scans Required for Medical Students to Achieve Competency in Clinical Settings**  
*Stephanie Gondra-Sanabria<sup>1</sup>,\* Richard Chyan<sup>1</sup>, Daniel Udrea<sup>1</sup>, Logan Villarreal<sup>1</sup>, Deanna Lo<sup>1</sup>, Andrew Sumnicht<sup>1</sup>, Vi Am Dinh<sup>2,3</sup>*

<sup>1</sup>School of Medicine, Loma Linda University, Loma Linda, CA USA; <sup>2</sup>Emergency Medicine, <sup>3</sup>Medicine, Division of Pulmonary and Critical Care, Loma Linda University Medical Center, Loma Linda, CA USA

**Objectives:** Despite its advantages in many medical settings, ultrasound (US) technology appears to be evolving at a quicker pace than US education. This may be attributed to the limited research demonstrating how many scans are needed for students to gain US proficiency. The purpose of this study is to evaluate the relationship between the number of US scans performed by medical students and (1) the quality of the US images acquired, (2) the ability to interpret pathology, and (3) student's comfort level.

**Methods:** Over an 8-week period, 5 medical students performed point-of-care US in the emergency department (ED). Prior to beginning, 16 SonoSim training modules were completed to provide students with a basic understanding of US pathology, followed by quizzes from the American College of Emergency Physicians (ACEP) to assess improvements in knowledge. Students scanned a variety of organ systems and reported their comfort levels during the exam. The overseeing physician then rated the image quality and interpretation. Confirmatory studies were reviewed to see if they agreed with the student's interpretation.

**Results:** Students completed 629 scans (mean, 125.8). They reported a significant increase in comfort levels by the 6th week for the following scans: cardiac (25 scans), inferior vena cava (11.8 scans), extended focused assessment with sonography for trauma (eFAST; 11.2 scans), renal (15.6 scans), pulmonary (7.2 scans), and soft tissue (5.4 scans). Image quality showed a significant increase in biliary (10 scans), eFAST (11.2 scans), renal (15.6 scans), and obstetric (4 scans) scans by week 6, and cardiac scans by week 8 (32.8 scans). Physicians agreed 95.1% of the time with the students' interpretation, and confirmatory studies agreed 82.3% of the time. ACEP test scores increased over time, with an average score of 51.4% prior to the students' completing the SonoSim modules to 85.6% 2 weeks after completing their ED rotation.

**Conclusions:** During an 8-week period, medical students improved their image acquisition and interpretation skills, and comfort levels while performing point-of care US across most organ systems. In addition, the SonoSim modules proved to be an adequate tool in improving students' understanding of US pathology prior to beginning their ED rotations.

**2384122 Soft Tissue Ultrasound and Failure of Therapy for Suspected Skin Abscesses**

*Romolo Gaspari,\* Alexandra Sanseverino*

Emergency Medicine, University of Massachusetts, Worcester, MA USA

**Objectives:** Bedside ultrasound for soft tissue infection is used to differentiate an abscess from cellulitis and to determine appropriate therapy. Our hypothesis was that failure of therapy following incision and drainage (I&D) was less than failure of therapy following expectant management without I&D.

**Methods:** We performed a retrospective multicenter review of patients presenting with a suspected abscess to the emergency department at 4 hospitals. Patients were eligible if they presented with signs and symptoms of an abscess and underwent soft tissue ultrasound. Patients' data were obtained from the electronic medical record. Patients were determined to fail therapy if they underwent I&D after being discharged from the emergency department. Patients discharged with a planned future I&D were not categorized as failure. Ultrasound images were blindly reviewed for accuracy. Comparison between groups was performed using a Fisher exact test.

**Results:** Over a 12-month period 718 soft tissue ultrasound exams were performed for a suspected abscess. Overall 399 (55.6%) ultrasound exams demonstrated an abscess, with the majority of those (310 or 77.8%) undergoing I&D. Failure rates for patients with a suspected abscess were similar regardless of intervention (I&D vs expectant management). Twenty-one of 328 (6.4%) patients who underwent I&D required a repeat I&D; 27 of 337 (8.0%) patients who underwent expectant management eventually required I&D; 85.3% of patients with a visible abscess cavity who did not undergo I&D were successfully treated with expectant management. Overall, 5.8% of patients with symptoms of an abscess but no sonographically visible abscess cavity eventually required I&D. Failure rates following expectant management were similar to failure rates following I&D (6.11% vs 5.56%;  $P = 1.0$ ).

**Conclusions:** With the use of ultrasound, failure rates of suspected abscesses following expectant management are low. Patients with no visible abscess cavity treated with expectant management fail therapy at a similar rate as visible abscess cavities treated with I&D. Some patients without sonographically visible abscess cavities can benefit from I&D. Conversely, not all sonographically visible abscess cavities need I&D.

**2384354 Emergency Physician Utilization of Ultrasound in Arizona**  
*Richard Amini<sup>1</sup>,\* Michael Wyman<sup>2</sup>, Nicholas Hernandez<sup>1</sup>, Srikar Adhikari<sup>1</sup>*

<sup>1</sup>Emergency Medicine, <sup>2</sup>College of Medicine, University of Arizona, Tucson, AZ USA

**Objectives:** Point-of-care ultrasound (POCUS) has been defined as an integral component to the practice of emergency medicine (EM). New guidelines require residents to demonstrate proficiency in POCUS, and nearly all academic EM programs provide dedicated ultrasound training. Previous studies have indicated that there remains variability in the use of ultrasound at nonacademic emergent care settings. The purpose of this study is to better understand the current use of POCUS in community nonacademic emergency departments (EDs) throughout the state of Arizona.

**Methods:** This was a cross-sectional study. An online questionnaire on the use of POCUS in the ED was electronically sent to all of the medical directors or ultrasound directors of each nonacademic ED in Arizona. The survey consisted of questions regarding demographics, current practice patterns, policies, interdepartmental agreements, and perceptions regarding the use of POCUS.

**Results:** A total of 70 community nonacademic EDs were identified for inclusion in our study. To date, 28 EDs have completed the survey, representing a 40% response rate. All (28/28) EDs have a dedicated ultrasound machine; 75% (95% confidence interval [CI], 56%–94%) of EDs perform or interpret POCUS for patient care. The 3 most common applications of POCUS in responders were focused assessment with sonography for trauma, cardiac ultrasound (for code arrest), and line placement. Only 40% (95% CI, 19%–61%) indicated that ultrasound experience is important in hiring decisions for ED physicians. Although 55% (95% CI, 33%–77%) of EDs have an ultrasound director or similar position filled, 80% (95% CI, 62%–98%) reported that they do not assess ED physicians in POCUS competency; 50% (95% CI, 28%–72%) of EDs indicated that they do not provide POCUS training; 65% (95% CI, 44%–86%) of EDs perform less than 20 ultrasound exams per week; and only 30% bill for POCUS.

**Conclusions:** In the state of Arizona, a majority of nonacademic EDs have access to ultrasound machines and have ultrasound privileges. However, only a small minority bill for ultrasound or provide regular assessment of this skill.



**2384358 Ultrasound-Assisted Lumbar Puncture in the Emergency Department**

**Jesse Spangler<sup>1</sup>, Rohit Manaktala<sup>1,\*</sup>, Jordan Tozer<sup>1</sup>, Michael Joyce<sup>1</sup>, Michael Vitto<sup>1</sup>, Jin Liu<sup>2</sup>, Adam Sima<sup>2</sup>, David Evans<sup>1</sup>**

<sup>1</sup>Emergency Medicine, <sup>2</sup>Biostatistics, Virginia Commonwealth University, Richmond, VA USA

**Objectives:** Ultrasound-guided procedures have become the standard of care for many procedures performed in the emergency department (ED). To date, there are limited data on whether ultrasound-assisted lumbar puncture (USA-LP) reduces the rate of LP failures among upper-level residents in the ED setting.

**Methods:** This pilot study took place in an urban academic ED serving more than 100,000 patients per year. The study randomized 27 patients to either USA-LP or a landmark technique over a 6-month period. In patients who were randomized to the USA-LP group, a curvilinear transducer (2–5 MHz) was placed on the patient's back in a transverse orientation. Lumbar spinous processes were identified and marked with a vertical line. The transducer was then placed in the sagittal orientation, and the L4–L5 interspace was found and marked with a horizontal line. The intersection of these marks was used as the site for LP needle insertion. The landmark group used palpation to identify the L4–L5 interspace in the standard fashion. Pain scores, time to cerebrospinal fluid (CSF) collection, number of cannulation attempts, body mass index, and CSF analysis were recorded on each patient.

**Results:** Twenty-seven patients were enrolled in the study: 12 in the landmark group and 15 in the USA-LP group. After randomization, 1 patient from the landmark group was excluded secondary to an intern performing the LP. In the USA-LP group 73.3% achieved successful LP, compared to 72.7% in the landmark group ( $P > .999$ ). The median times from consent to obtaining CSF were 55 minutes in the USA-LP group and 32 minutes in the landmark group ( $P = .591$ ). Using a Likert 11-point pain scale to assess pain during the procedure, the USA-LP group's mean pain score was 6.93/11, and the landmark group's mean pain score was 4.0/11 ( $P = .722$ ). The average numbers of attempts prior to successful LP were 2.0 in the USA-LP group and 3.08 in the landmark group ( $P = .0458$ ).

**Conclusions:** Ultrasound guidance did not affect the rate of LP failure by trainees; however, there appear to be fewer attempts needed to obtain CSF. Our hope is that further enrollment and completion of this study will ascertain the true utility of ultrasound guidance for LP in the academic setting.

## SCIENTIFIC SESSIONS

SATURDAY, MARCH 19, 2016, 4:00 PM–5:30 PM

## Elastography

Moderator: Richard Barr, MD, PhD

**2381698 Ultrasound Elastography: Variation of Fibrosis Assessment as a Function of Depth, Force, and Distance From the Central Axis of the Transducer With a Comparison of Different Systems**Changtian Li<sup>1,\*</sup>, Luzeng Chen<sup>1</sup>, Zhikui Chen<sup>1</sup>, David Cosgrove<sup>2</sup>, Atul Bhan<sup>3</sup>, Dahlene Fusco<sup>3</sup>, Manish Dhyani<sup>1,3</sup>, Anthony Samir<sup>1</sup><sup>1</sup>Abdominal and Interventional Radiology, Massachusetts General Hospital, Boston, MA USA; <sup>2</sup>Hammersmith Hospital, London, England; <sup>3</sup>Massachusetts General Hospital, Boston, MA USA

**Objectives:** To evaluate the accuracy of ultrasound elastography in the assessment of fibrosis using different systems and to assess variation at different depths, forces, and distance from the central axis of the transducer.

**Methods:** In this Institutional Review Board–approved single-institution prospective study, 20 patients underwent elastographic assessment on 3 systems (FibroScan, Siemens, and SuperSonic). All subjects had undergone nonfocal liver biopsy within the past 6 months as part of their clinical care, and biopsy was evaluated by the METAVIR system (F0–F4). Acoustic radiation force impulse and shear wave elastographic measurements were obtained at different depths (3, 5, and 7 cm), 3 different forces (4, 7, and 10 N), and 2 and 4 cm off axis. FibroScan was also performed on the same day. Spearman correlations of shear wave speed with fibrosis stage were calculated and the area under the receiver operating characteristic curves (AUROC) to differentiate  $\geq$ F2 fibrosis from lesser grades (F0 and F1) was charted.

**Results:** A total of 20 subjects (male:female = 12:8) with a mean age of 54 years and varying fibrosis stages (F0 = 4, F1 = 9, F2 = 3, F3 = 2, and F4 = 2) participated in the study. FibroScan values showed high correlation with the fibrosis stage ( $r = 0.579$ ;  $P = .009$ ) and an AUROC of 0.88. For the Siemens system, there was a statistically significant difference ( $P = .003$ ) between values obtained at 3 different depths, with the highest correlation ( $r = 0.667$ ;  $P = .001$ ) and AUROC at a depth of 7 cm. Similarly, for the SuperSonic system, the correlation ( $r = 0.620$ ;  $P = .004$ ) and AUROC were highest at a depth of 7 cm, but the difference across depths was not statistically significant. Variation in preload force at a 5-cm measurement depth made no statistically significant difference. Measurements along the central axis had the highest AUROC for both the Siemens (0.846; 95% confidence interval [CI], 0.669–1.023) and SuperSonic (0.764; 95% CI, 0.547–0.981) systems.

**Conclusions:** (1) In this small study, the SuperSonic and Siemens system performed best for differentiation between advanced fibrosis ( $F \geq 2$ ) and lesser or no fibrosis (F0 and F1) at a depth of 7 cm along the central axis. (2) Preload force variations between 4–10 N do not appear to affect measurements made via an intercostal approach.

**2383952 Ultrasound Strain Elastography in Assessment of Resting Biceps Brachii Muscle Stiffness in Patients With Parkinson's Disease: A Primary Observation**Jing Gao<sup>1,\*</sup>, Li-Juan Du<sup>2</sup>, Wen He<sup>2</sup>, Shuo Li<sup>2</sup>, George Shih<sup>1</sup>, Keith Hentel<sup>1</sup>, Jonathan Rubin<sup>3</sup><sup>1</sup>Radiology, Weill Cornell Medical College, New York, NY USA;<sup>2</sup>Ultrasound, Beijing Tiantan Hospital–Capital Medical University, Beijing, China; <sup>3</sup>Radiology, University of Michigan, Ann Arbor, MI USA

**Objectives:** The aim of this study was to evaluate the feasibility of ultrasound strain elastography (SE) for the assessment of resting biceps brachii muscle (BBM) stiffness in patients with Parkinson's diseases (PD).

**Methods:** From May 2014 to December 2014, we prospectively performed SE of BBM in 14 patients with PD and 10 healthy controls. Based on the Unified Parkinson's Disease Rating Scale for scoring muscle rigidity (UPDRS, part III), patients were divided into a high-rigidity (UPDRS III–IV,  $n = 3$ ) group and a low-rigidity (UPDRS I–II,  $n = 11$ ) group. Ultrasound strain was represented by the deformation of the BBM and subcutaneous soft tissues that was produced by external compression with a sand bag (1.5 kg) tied onto an ultrasound transducer. Deformation was estimated with 2D speckle tracking. The difference in strain ratio (SR, mean BBM strain/mean subcutaneous soft tissue strain) among high-rigidity patients, low-rigidity patients, and healthy controls was tested by analysis of variance, and the difference in each paired group was then examined by the Bonferroni test. The correlation between SR and muscle rigidity score was analyzed by the Pearson correlation coefficient. The reliability of SR in assessment of BBM stiffness was tested using the intraclass correlation coefficient (ICC).

**Results:** The SR in high-rigidity patients, low-rigidity patients, and healthy controls measured  $1.91 \pm 0.31$ ,  $2.95 \pm 0.36$ , and  $3.30 \pm 0.27$ , respectively. A significant difference in SR was noted among the 3 groups ( $P = .000$ ), as well as between paired groups (all  $P < .05$ ). A negative correlation was found between SR and UPDRS rigidity score ( $r = -0.78$ ). The ICC for SR in assessment of BBM stiffness was 0.88.

**Conclusions:** Our study suggests that the SR of BBM to reference tissue can be used as a quantitative biomarker in assessing resting muscle stiffness associated with muscle rigidity in PD.

**2384881 Summative Elastography Score Is Superior to Single-Plane Elastography Score in Dupuytren's Cord Treatment**Andrew DeMarco<sup>3,\*</sup>, Megan Bishop<sup>1,4</sup>, Theresa BassGoldman<sup>1,4</sup>, Paul DeMarco<sup>1,2,4</sup><sup>1</sup>Arthritis and Rheumatism Associates, PC, Wheaton, MD USA;<sup>2</sup>Rheumatology/Internal Medicine, Georgetown University School of Medicine, Washington, DC USA; <sup>3</sup>Duquesne University, Pittsburgh, PA USA; <sup>4</sup>Clinical Trials Department, Center for Rheumatology and Bone Research, Wheaton, MD USA

**Objectives:** To determine if a calculated index from orthogonal planes, when compared to single-plane scoring, would be statistically significantly more likely to detect elastographic changes during treatment of Dupuytren's cords with collagenase clostridium histolyticum (CCH).

**Methods:** An Institutional Review Board–approved pilot protocol established elastography of 5 normal hands, 5 untreated Dupuytren's cords, and 10 Dupuytren's cords treated with CCH. Serial elastography during CCH treatment was performed using a GE LOGIQ S8 with compatible elastographic software. Standardized imaging (Table 1) of either the normal palmar aponeurosis or a Dupuytren's cord (with or without exposure to CCH) was collected at designated times. Images were graded with a scale of 1–4. Statistical analysis was performed on the individual planes and on a summative score, the weighted elastographic score (wES), accounting for orthogonal planes. Statistical analysis was assessed with the Shapiro-Wilk, Student  $t$ , or Pearson  $\chi^2$  test.

**Results:** Elastography of individual regions of normals showed an average score of 1, while untreated Dupuytren's cords showed an average of 3. The elastography of individual regions of the treated Dupuytren's cord on days 1 and 30 (see Table 1) was not statistically significant. The wES of normals was 7.65, while that of untreated Dupuytren's contracture was 11.4; the treated Dupuytren's contracture score reached statistical significance (Table 1).

**Conclusions:** The pilot established the ability for elastography to act as an outcome measure after application of a therapeutic. The wES performed better than individual scores. This suggests that evaluation of organ response in orthogonal planes may be superior to a single-view measurement and has significant implications for data collection and sample sizes. Further study of this effect in other organ systems is warranted.

Table 1

Region for Elastographic Measurement	Day 1 Elastographic Score	Day 30 Elastographic Score	P
Midline sagittal	3.0	2.3	NS
Distal transverse	2.7	2.5	NS
Middle transverse	2.6	2.5	NS
Proximal transverse	2.9	2.0	NS
Weighted elastographic score	11.6	8.8	<.05

NS indicates not significant.

#### 2384911 Three-Dimensional Reconstruction in Ultrasound Elastography Using a Markov Random Field Model

Atul Ingle,\* Tomy Varghese

University of Wisconsin-Madison, Somerville, MA USA

**Objectives:** This work aims to develop a computationally tractable algorithm capable of reconstructing a complete volume on a fine grid in 3D from a scattered cloud of shear wave velocity (SWV) measurements obtained using electrode vibration shear wave elastography.

**Methods:** An electrode vibration SWV experiment was performed on a tissue-mimicking phantom consisting of a stiff ellipsoidal inclusion surrounded by softer background material. A needle, which was firmly bonded to the inclusion, was vibrated using an actuator operated in synchronization with a high-frame rate radiofrequency ultrasound data acquisition routine on a research ultrasound scanner. A 128-element linear array ultrasound transducer with a center frequency of 5 MHz was used, and axial displacements were tracked using a 2-mm window with 50% overlap. The laterally traveling shear wave pulse vibration was tracked as a function of distance away from the needle in the image plane, and SWV was estimated using time of arrival processing. This experiment was repeated in a sheaf geometry over different imaging planes by rotating the ultrasound transducer around the needle, and SWV maps were generated on each plane. A Markov random field (MRF) model was used to generate a visualization on a fine grid of points in 3D. An iterative reconstruction algorithm was used to estimate the mode of the joint distribution of the values on all the grid nodes. Quantitative estimates of SWV were obtained by averaging over 2 cuboidal regions of interest in the stiff and soft regions of the phantom. A standard nearest neighbor (NN) interpolation algorithm was used for comparison.

**Results:** Visual comparison suggests that NN reconstruction appears more blocky than MRF reconstruction. Quantitative estimates suggest that the values obtained from the MRF algorithm agree with those obtained from standard NN interpolation, but the MRF method provides up to a 2-dB better signal-to-noise ratio.

**Conclusions:** This work presented an iterative reconstruction algorithm for 3D visualization of SWV obtained from electrode vibration elastography. This model-based method is quite general and can be applied to other quantitative measurements as well.

#### 2384985 Assessment of Liver and Spleen Stiffness in Patients With Myelofibrosis Using FibroScan and Shear Wave Elastography

Muriel Webb

Gastroenterology, Ikhilov Hospital, Tel Aviv, Israel

**Objectives:** To date, the liver and spleen stiffness in patients with myelofibrosis was assessed by manual palpation, thus influenced by interobserver variability. In this work, for the first time, the liver and spleen stiffness of patients with myelofibrosis was evaluated using FibroScan and shear wave elastography (SWE).

**Methods:** The study included 9 patients with myelofibrosis, and 11 patients with liver cirrhosis and 8 healthy volunteers served as 2 control groups.

**Results:** In myelofibrotic patients, the mean stiffness of the spleen was 41.3 and 32.9 kPa by FibroScan and SWE, respectively, and was not related to spleen size. The stiffness of the liver was 7.8 kPa for FibroScan and 10.4 kPa for SWE. The stiffness of the spleen in cirrhotic patients was even higher, reaching a mean of 58.5 kPa in FibroScan and 37.5 kPa in SWE, but the correlation among cirrhotic patients was inferior in comparison to patients with myelofibrosis, with  $r = 0.35$  and  $r = 0.78$ , respectively.

**Conclusions:** FibroScan and SWE may serve as tools for evaluation of response to treatment in patients with myelofibrosis.

#### 2387759 Sonoelastography, B-Mode Sonography, and Color Doppler Sonographic Findings of Pleomorphic Adenoma and Warthin Tumors of the Parotid Gland

Hasan Yerli

Baskent University, Izmir, Turkey

**Objectives:** To research the sonoelastographic (SE), B-mode sonographic, and color Doppler sonographic findings of pleomorphic adenoma and Warthin tumors of the parotid gland and to determine the contribution of the SE method to the differentiation of the pleomorphic adenoma and Warthin tumors after B-mode and color Doppler sonographic examinations.

**Methods:** Forty-eight parotid masses in 72 patients (23 pleomorphic adenomas and 25 Warthins) were retrospectively evaluated. For each lesion, B-mode sonographic, color Doppler sonographic, and SE images were evaluated. Vascularity of the tumors during the color Doppler sonographic examinations was determined with a 4-scoring method, and qualitative categorization was also applied if there was any vascularity in the tumor. Elasticity scores of the tumors during the SE examinations were determined with the 4-scoring method. Differences among the pleomorphic adenomas and Warthin tumors were assessed using the Student *t* test.

**Results:** The presence of a lobulated contour and cystic area was more common in the pleomorphic adenomas and Warthin tumors, respectively, during the B-mode sonographic examinations. Peripheral vascularity was seen in more than half of pleomorphic adenoma cases. Central or mixed vascularity was seen in a large group of Warthin tumor cases. The mean scores on color Doppler sonography were  $1.13 \pm 0.81$  for pleomorphic adenomas and  $1.96 \pm 0.97$  for Warthin tumors. The mean scores on SE were  $2.69 \pm 0.70$  for pleomorphic adenomas and  $1.83 \pm 0.63$  for Warthin tumors ( $P < .05$ ). Score 1 on SE was determined in 3 cases of 5 Warthin tumors showing peripheral vascularity on color Doppler sonography.

**Conclusions:** B-mode, color Doppler, and elastography examinations by sonography provide some helpful findings in the differentiation of pleomorphic adenoma and Warthin tumors.

## Musculoskeletal Ultrasound

*Moderator: Humberto Rosas, MD*

### 2377365 Multifidi Activity Helps Explain Clinical Measures in Older Adults With Low Back Pain

*J. Megan Sions<sup>1</sup>,\* Peter Coyle<sup>2</sup>, Teonette Velasco<sup>1</sup>, Gregory Hicks<sup>1</sup>*

<sup>1</sup>Physical Therapy, <sup>2</sup>Biomechanics and Movement Science Program, University of Delaware, Newark, DE USA

**Objectives:** To determine if lumbar multifidi activity, as obtained with ultrasound imaging, helps explain disability, balance confidence, and physical performance among older adults with low back pain (LBP).

**Methods:** A total of 221 older adults, ages 60–85 years, with LBP, participated in a clinical examination that included the Oswestry Disability Index (ODI), the Activity-Specific Balance Confidence Scale (ABC), physical performance testing, ie, 6-Minute Walk Test (6MWT), and assessment of self-selected gait speed using a computerized walkway. Following the examination, a blinded examiner performed ultrasound imaging of the bilateral L3–4 multifidi, using a MyLab 25 portable ultrasonography unit (Biosound Esaote, Inc, Indianapolis, IN). Ultrasound images were taken at rest and during an isometric contraction facilitated with a straight leg raise. Percent thickness change was calculated to determine multifidi activity. Regression modeling was used to determine the variance of the measure explained by average multifidi activity, above and beyond covariates. Age, sex, and body mass index were entered in the first block, followed by current LBP in the second block and multifidi activity in the third block.

**Results:** For the ODI, the model explained 17.2% of the variance, with pain explaining 6.6% of the variance ( $P = .000$ ) and multifidi activity explaining 4.2% of the variance ( $P = .001$ ). For the ABC, the model explained 17.8% of the variance, with pain explaining 7.2% of the variance ( $P = .000$ ) and multifidi activity explaining 4.7% of the variance ( $P = .000$ ). For 6MWT, the model explained 27.6% of the variance, with pain explaining 1.6% of the variance ( $P = .036$ ) and multifidi activity explaining 9.4% of the variance ( $P = .000$ ). For self-selected gait speed, the model explained 13.3% of the variance, with pain explaining 0% of the variance ( $P = .813$ ) and multifidi activity explaining 4.0% of the variance ( $P = .002$ ).

**Conclusions:** Findings suggest that multifidi activity may be an independent factor that helps explain LBP-related disability and balance confidence among older adults, but to a lesser degree than LBP intensity. However, multifidi activity may be a more important factor than LBP intensity with respect to walking performance.

### 2327733 Musculoskeletal Ultrasound in American Occupational Medicine Residency Programs: A Survey of Program Directors

*Yusef Sayeed<sup>1</sup>,\* Anna Allen<sup>1</sup>, Joseph Minardi<sup>2</sup>, Hussam Kurdi<sup>1</sup>, Charles Werntz<sup>1</sup>*

<sup>1</sup>Occupational Medicine, <sup>2</sup>Emergency Medicine, West Virginia University, Morgantown, WV USA

**Objectives:** The objectives of this study were 2-fold: describe the current state of musculoskeletal (MSK) ultrasound (US) training in occupational medicine (OM) residency programs and to gauge interest in MSK US among program directors (PDs).

**Methods:** A Web-based survey was sent to all 22 United States OM residency programs.

**Results:** Fifty-nine percent (13 of 22) of program directors completed the survey, with 2 assistant program directors completing the survey, for a total of 15 responses. Ninety-three percent of programs have an OM clinic, yet no programs offer access to MSK US in the clinic. Twenty-three percent of the responders reported including any MSK US

training (formal and informal courses), with 1 respondent reporting 6–10 hours of exposure being the maximum amount of time; 23% of respondents report providing resident's access to US machines for training purposes outside the OM clinic; 77% of respondents indicated that they were interested in attending MSK US training and bringing this skill set back to their institution.

**Conclusions:** There is a disparity between OM program directors' desire to use and be trained in MSK US and the presence of US machines in clinic. The interest in learning MSK US clearly exceeds the portion of residency programs including this in their curricula. This level of interest suggests this modality will become increasingly useful for diagnosis and interventions as clinical practices evolve.

### 2369886 Preloaded Machine Protocols: Are They Better Ways to Ensure a Complete Shoulder Ultrasound Exam?

*Akash Garg,\* Patricia Delzell, Jennifer Bullen, Naveen Subhas*  
Cleveland Clinic Foundation, Cleveland, OH USA

**Objectives:** The AIUM protocol for a complete shoulder ultrasound (US) exam requires documentation of a number of structures in orthogonal planes. We observed that, despite training US technologists to follow the protocol, we routinely had incomplete exams. Therefore, we preloaded the US machine with the labels of all the required images in the order of scanning such that after an image is captured, the label for next required image would automatically appear on the screen. This study evaluated if machine labeling of images resulted in a higher rate of complete exams compared to manually labeling images.

**Methods:** Shoulder US exams of 22 consecutive patients from 1/2010–8/2010 before machine labeling of exams and 20 consecutive patients from 1/2013–2/2013 after machine labeling of exams were retrospectively reviewed. A 24-month window after implementation of machine labeling was selected to ensure familiarity with the new system. All exams were performed by the same 8 technologists with at least 2 years of experience using the AIUM protocol. Exams scanned by other technologists were excluded. All exams were reviewed by a single reviewer for the presence of 32 specific images/cine clips required by the protocol. The frequency of obtaining each required image for each group was then calculated.

**Results:** All of the machine-labeled exams resulted in a complete exam compared to none of the manually labeled exams. Specifically, power Doppler images of the subacromial-subdeltoid bursa and cine clips for dynamic evaluation of shoulder impingement, both of which are common causes of shoulder pain, were evaluated in only 9% (2/22) and 0% of the manually labeled exams, respectively. Images of the supraspinatus and infraspinatus muscles, posterior joint, and spinoglenoid notch, which are not common causes of shoulder pain but part of the required protocol, were not captured in any of the manually labeled exams.

**Conclusions:** Shoulder US exams performed using machine labeling of images always resulted in a complete exam compared to manual labeling of images, where required images of important structures were routinely not captured. Using preloaded protocols for technologists performing shoulder US exams can help ensure a complete examination.



**2384646 Ultrasound-Guided Platelet-Rich Plasma Injection: Clinical Outcomes in Patients With Patellar Tendinopathy Following Anterior Cruciate Ligament Reconstruction Using a Patellar Tendon Autograft**

*Garrett Woodbury<sup>1</sup>, \* John Wilson<sup>2</sup>, Kari Taggart<sup>2</sup>, Geoffrey Baer<sup>2</sup>, Tim McGuine<sup>2</sup>, Ken Lee<sup>1</sup>*

<sup>1</sup>Radiology, <sup>2</sup>Orthopedics, University of Wisconsin, Madison, WI USA

**Objectives:** Anterior cruciate ligament (ACL) reconstruction utilizing a patellar tendon autograft can cause patellar tendinopathy (PT), leading to decreased function, activity level, and postoperative satisfaction. When conservative measures have not provided pain relief, platelet-rich plasma (PRP) injection has been proposed as an additional treatment option to augment patellar tendon healing, alleviate pain, and improve function. The purpose of this study is to evaluate the efficacy of PRP in improving knee function and pain in patients suffering from PT after ACL reconstruction and to describe our ultrasound (US)-guided technique in targeting diseased tendon tissue.

**Methods:** A retrospective analysis was performed to evaluate the efficacy of PRP injection in alleviating pain related to PT. The study group included 11 patients (9 females, 2 males; average age,  $19 \pm 2.19$  years) with PT recalcitrant to a myriad of conservative treatments following an ACL reconstruction utilizing a patellar tendon autograft. Each patient was diagnosed with PT and received a US-guided intratendinous PRP injection of the proximal patellar tendon. Injections were performed  $34.8 \pm 17.1$  weeks after ACL reconstruction. Each patient completed the 2000 International Knee Documentation Committee (IKDC) scores before injection and at  $29.5 \pm 17.7$  weeks after PRP injection.

**Results:** IKDC preinjection values were 48.3 (44.3, 60.3), while postinjection values were 74.7 (52.9, 82.8). Postinjection scores were significantly higher (13.8 [1.1, 33.0];  $P = .02$ ). Seven (64%) patients showed clinically significant improvement in their IKDC scores, while 4 (36%) showed no clinically significant change. The primary outcome variable was the paired differences of IKDC scores (preinjection to postinjection) for each patient assessed with the Wilcoxon signed rank test ( $P \leq .05$ ) and reported as the median (interquartile ranges: 25th and 75th). A change of 12 points in the IKDC for patients was considered clinically significant.

**Conclusions:** US-guided PRP injection may be a viable treatment option for patients with PT following ACL reconstruction with a patellar tendon autograft.

**2385559 Ethnicity Does Not Affect Cross-Sectional Areas of Major Upper Extremity Nerves on Ultrasound**

*Nathan Anderson<sup>2</sup>, \* Leland Finley<sup>2</sup>, Bryce Betteridge<sup>2</sup>, Weston Pratt<sup>2</sup>, Jongyeol Kim<sup>1</sup>*

<sup>1</sup>Neurology, Texas Tech University Health Sciences Center, Lubbock, TX USA; <sup>2</sup>Texas Tech University Health Sciences Center School of Medicine, Lubbock, TX USA

**Objectives:** Age, gender, and body mass index (BMI) are known to affect cross-sectional area (CSA) of peripheral nerves on ultrasound. However, the effect of race on the CSA of nerves is not well defined. Normal CSAs of median and ulnar nerves of healthy volunteers from 3 different ethnicity groups were compared to investigate the effect of race on nerve size.

**Methods:** A total of 120 healthy subjects of 3 different races (Caucasian, 20 M, 20 F; African American, 20 M, 20 F; Mexican American, 20 M, 20 F), aged between 18 and 30 years, were recruited. Measurements were made at 5 standard points along each nerve in the upper limb. Anthropometric data (age, height, weight, fat mass, muscle mass, total body water, bone mass, basal metabolic rate, metabolic age, visceral fat rating, BMI, and degree of obesity [%]) were recorded.

**Results:** There was no statistically significant difference in nor-

mal values of CSA of median and ulnar nerves at 5 spots between races after adjusting for other confounders. Females showed smaller CSA at each point ( $P < .05$ ), but the difference between genders was insignificant when controlled for fat-free mass index (FFMI). Contrary to previous studies, BMI did not show any significant correlation with sex.

**Conclusions:** For ultrasound of major upper extremity nerves, race-specific reference values will not be needed, but normative data of CSAs should be obtained according to anthropometric parameters, including FFMI and gender. FFMI has the potential to be a powerful indicator for explaining differences in nerve CSA.

**2377749 The arcTOA Technique for Out-of-Plane Ultrasound-Guided Injections: Technique Description and Comparison Study**

*Sathish Rajasekaran<sup>1</sup>, \* Jonathan Finnoff<sup>2,3</sup>*

<sup>1</sup>Orthopedics and Rehabilitation, University of Iowa Sports Medicine, Iowa City, IA USA; <sup>2</sup>Physical Medicine and Rehabilitation, Mayo Clinic School of Medicine, Rochester, MN USA; <sup>3</sup>Physical Medicine and Rehabilitation, University of California Davis School of Medicine, Sacramento, CA USA

**Objectives:** To describe the trigonometric function angle equals arctan of the opposite side divided by adjacent side for out-of-plane ultrasound-guided injections (arcTOA technique) and determine if this technique resulted in fewer needle passes and less time for physical medicine and rehabilitation (PM&R) residents to accurately place a needle tip into targets at various depths in an ultrasound phantom than the modified walk-down technique.

**Methods:** The arcTOA technique was described. Then participants performed ultrasound-guided injections in gelatin models into 5 targets located between 1 and 5 cm in depth using the arcTOA and modified walkdown techniques. The target depth and technique order were randomized. The number of needle passes required to reach the target was the primary outcome measure. The secondary outcome measure was the time taken to reach the target.

**Results:** The mean number of needle passes and duration of time required to successfully complete the procedure by all participants using the arcTOA technique were significantly less than those for the modified walkdown technique ( $P < .001$ ).

**Conclusions:** Our findings suggest that when using the arcTOA technique, PM&R residents are able to accurately place a needle into a target at various depths in a phantom using less needle passes and less time when compared to the walkdown technique. Thus, educators may wish to consider using this technique when teaching residents how to perform OOP injections. Future studies need to assess whether these results are reproducible in the clinical setting and when used by experienced interventional sonographers.

**Obstetric Ultrasound: Uterus, Placenta, and Cervix**

*Moderator: Anna Monteagudo, MD*

**2378589 Utility of Volumetric Assessment of Cervical Funneling to Predict Cerclage Failure**

*Jessica Sheng, \* Frank Schubert, Avinash Patil*

*Indiana University School of Medicine, Indianapolis, IN USA*

**Objectives:** Cervical funneling has been found to be predictive of poor obstetric outcomes; however, the value of volumetric assessment is not clear. We seek to assess the utility of volumetric measurement cervical funneling as a predictor of cerclage failure.

**Methods:** We performed a retrospective cohort study of pregnant women with a McDonald cerclage and sonographic evidence of cervical funneling between 1/2008 and 2/2014 at an academic medical center. Funnel volume (FV) was calculated from cervical measurements and used

as a correction factor for individual subject cervical length (CL) or cerclage height (CH) parameters. Receiver operating characteristic (ROC) curves were used to determine the predictive value of CL, CL:FV, CH, and CH:FV for cerclage failure at <28 or <36 weeks. CL:FV obtained at the initial ultrasound after cerclage placement was further stratified to the <5th, <10th, and >10th percentiles and analyzed by a *t* test to determine if these thresholds were predictive of preterm delivery at <28 or <36 weeks.

**Results:** Of 57 patients with a cerclage and sonographic evidence of cervical funneling, 30 patients had a cerclage failure. The mean gestational age at birth was  $29.8 \pm 5.3$  weeks in the failure group compared to  $38.1 \pm 1.4$  weeks in those that did not fail ( $P < .001$ ). ROC curves demonstrated that CL, CL:FV, and CH:FV were predictive for cerclage failure <28 weeks' gestation ( $P = .003$ ;  $P = .001$ ;  $P = .03$ , respectively). CL:FV demonstrated the largest area under the curve (CL:FV AUC, 0.80; vs CL AUC, 0.77) for prediction of delivery <28 weeks. CL alone had the largest AUC (0.76) for prediction of delivery <36 weeks. The mean gestational age at delivery was significantly lower in subjects with CL:FV <5th percentile compared to >10th percentile ( $25.1$  vs  $34$  weeks;  $P = .01$ ) and 5th–10th ( $25.1$  vs  $33.3$  weeks;  $P = .08$ ).

**Conclusions:** Volumetric assessment of the cervical funnel may improve the ability of existing cervical morphologic parameters to predict cerclage failure in a high-risk population in the midtrimester.

### 2377958 More Data Supporting That Intra-Amniotic “Sludge” Does Not Affect Pregnancy Outcome in Patients Undergoing Cerclage for a Sonographically Short Cervix

*Fereshteh Boozarjomehri<sup>1</sup>, \*Margaret Dziadosz<sup>2</sup>, Morgan Peltier<sup>1</sup>, Fatima Boozarjomehri<sup>3</sup>, Anthony Vintzileos<sup>1</sup>, Ilan Timor-Tritsch<sup>2</sup>, Frederick Naftolin<sup>2</sup>*

<sup>1</sup>Obstetrics and Gynecology, Winthrop University Hospital, Garden City, NY USA; <sup>2</sup>Obstetrics and Gynecology, New York University School of Medicine, New York, NY USA; <sup>3</sup>Swarthmore College, Swarthmore, PA USA

**Objectives:** Previously we showed that the finding of intra-amniotic “sludge” (IAS), an ultrasound (US) finding of hyperechoic matter in the amniotic fluid (AF) close to the cervical internal os, did not change the pregnancy outcome in asymptomatic patients (pts) undergoing cerclage for a sonographically short cervix (Cx). We aim to find if addition of 22 pts to our previously reported 46 would change the results.

**Methods:** Case records of 68 consecutive pts, who underwent McDonald cerclage at 16–24 6/7 weeks' gestation for a sonographically short Cx (<25 mm) between 2007–2015 were evaluated. Transvaginal US images were reviewed for cervical length, funneling, and presence of IAS. Baseline morphologic characteristics and pregnancy outcomes were compared between those with and without IAS.

**Results:** Of the 68 pts, 36 (53%) had IAS present, and 32 (47%) did not. Comparison of the 2 groups is shown in Table 1. Pts with IAS had significantly shorter cervical lengths at the time of cerclage,  $9.9 \pm 7$  vs  $13.7 \pm 6.7$  mm ( $P = .025$ ) and more frequently had cervical funneling ( $P = .022$ ). Other baseline characteristics were largely similar. One patient without IAS was lost to follow-up.

**Conclusions:** Despite associated differences in Cx funneling and shorter Cx, the presence of IAS did not affect pregnancy outcome in terms of gestational age at birth or neonatal birth weight. These results suggest that the presence of IAS does not contraindicate the use of cerclage in asymptomatic pts who are candidates for cerclage.

Table 1

Pregnancy Outcome	Sludge (n = 36)	No Sludge (n = 32) (1 pt Lost to Follow-up)	P
Gestational age at delivery, wk <sup>1</sup>	36 1/7 ± 4	36 4/7 ± 4 2/7	.719 <sup>a</sup>
Delivery at <24 wk <sup>2</sup>	1/36 (2.8)	1/31 (3.2)	1.000 <sup>b</sup>
Delivery at <25 wk <sup>2</sup>	1/36 (2.8)	1/31 (3.2)	1.000 <sup>b</sup>
Delivery at <28 wk <sup>2</sup>	1/36 (2.8)	2/31 (6.5)	.592 <sup>b</sup>
Delivery at <32 wk <sup>2</sup>	5/36 (13.9)	4/31 (13)	1.000 <sup>b</sup>
Delivery at <34 wk <sup>2</sup>	9/36 (25)	5/31 (16.1)	.548 <sup>b</sup>
Delivery at <37 wk <sup>2</sup>	16/36 (44)	11/31 (35.5)	.618 <sup>b</sup>
Baby weight, g <sup>3</sup>	2745 (808)	2938 (827)	.356 <sup>c</sup>

<sup>1</sup>Median (minimum, maximum); <sup>2</sup>proportion (%); <sup>3</sup>mean (SD).

<sup>a</sup>Wilcoxon test; <sup>b</sup>Fisher test; <sup>c</sup>*t* test.

### 2380128 Prospective Evaluation of Postpartum Uterine Sonographic Measures Following Vaginal and Cesarean Deliveries

*Eran Ashwal, Kinneret Tenenbaum-Gavish, Hila Zilber, Liran Hirsch, Arnon Wiznitzer, Yaviv Yogev, Israel Meizner, Ron Bardin\**

*Helen Schneider Hospital for Women, Rabin Medical Center, Petah Tiqwa, Israel; Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel*

**Objectives:** We aimed to prospectively describe uterine sonographic features following vaginal and cesarean deliveries.

**Methods:** Transabdominal ultrasound examination was performed within 3 days following vaginal deliveries (VD; n = 103) and lower-segment cesarean section (LSCS; n = 34). The uterine length, width, and height as well as endometrial thickness at the fundus, midlength of the corpus uteri, and proximal cervical canal were measured.

**Results:** (1) No significant differences were found with respect to mean uterine length ( $127.7 \pm 25.5$  vs  $126.0 \pm 22.9$  cm), width ( $123.0 \pm 16.8$  vs  $117.8 \pm 14.5$  cm), and height ( $91.2 \pm 16.3$  vs  $86.0 \pm 13.6$  cm) between women with VD compared to LSCS. The mean endometrial thickness at the fundus ( $9.0 \pm 5.3$  vs  $8.2 \pm 4.2$  mm), at midlength uteri ( $8.3 \pm 4.0$  vs  $8.5 \pm 3.4$  mm), and at the proximal cervical canal ( $14.6 \pm 8.6$  vs  $12.6 \pm 5.1$  mm) was comparable between women with VD and LSCS. Uterine and endometrial measurements were comparable for women who underwent early postpartum hemorrhage (PPH) or uterine revision (n = 28) to those who did not (n = 75). (2) Overall, 80 women underwent 2 consecutive measurements at <36 and 36–72 hours. No significant change was observed regarding endometrial thickness at the fundus or proximal cervical canal. The endometrial thickness at midlength uteri increased in the 2nd measurement ( $9.5 \pm 5.3$  vs  $8.3 \pm 3.7$  mm;  $P = .01$ ). Endometrial irregularity was significantly demonstrated in the 2nd measurement. Among women following VD, endometrial thickness at the fundus site ( $6.7 \pm 2.5$  vs  $9.7 \pm 4.8$  mm;  $P < .001$ ) and at midlength uteri ( $6.7 \pm 2.5$  vs  $8.7 \pm 3.9$  mm;  $P = .01$ ) as well as uterus width ( $117.4 \pm 17.5$  vs  $125.9 \pm 15.9$  mm;  $P = .03$ ) were significantly lower in nulliparous compared to multiparous women. (3) Overall, the time interval from delivery had no clinical effect on various outcome measurements.

**Conclusions:** There were no significant differences between uterine and endometrial measurements during the first 3 days postpartum. Sonographic parameters were significantly affected by parity but not by PPH, uterine revision, or mode of delivery.

### 2382045 Relationship of Cervical Length With Need for Adjuvant Progesterone and Pregnancy Outcomes in Women With Cerclage

Rachel Sinkey,\* Mercedes Garcia, Anthony Odibo

Obstetrics and Gynecology, University of South Florida, Tampa, FL USA

**Objectives:** The benefit of progesterone (P) therapy as an adjunct to cerclage (C) is unclear. Our objective is to investigate the relationship of cervical length (CL) with need for adjuvant P and pregnancy outcomes among women with C.

**Methods:** A retrospective cohort review was performed by identifying women undergoing vaginal C placement from 10/2011–6/2015 within the surgery database. Patients were included if they had a singleton gestation and subsequently used P (either intramuscular P [17P] or vaginal P [VagP]). Patients were excluded if they had a multiple gestation, simultaneously used 17P and VagP, had no precerclage CL, or were lost to follow-up. Controls included women with C with singleton pregnancies who did not use P and were not lost to follow-up. The Student *t* test and  $\chi^2$  tests were used as appropriate. Logistic regression was used to create receiver operating characteristic curves, and the area under the curve (AUC) was of primary interest.

**Results:** Sixty-two patients met inclusion criteria. Twenty-five (40%) patients with C subsequently started P; 37 (60%) had C alone. Mean gestational age (GA) at C placement was earlier for women who subsequently used P:  $16.9 \pm 3.0$  vs  $18.6 \pm 3.2$  weeks ( $P = .03$ ). CL among women who subsequently used P was  $26.52 \pm 13.5$  mm as compared to the C-only group:  $20.4 \pm 14.5$  mm ( $P = .10$ ). Among women who used P, it was initiated at mean GA of  $18.5 \pm 3.7$  weeks. GA at delivery was similar between groups:  $34.3 \pm 5.8$  weeks in the adjuvant P group vs  $36.2 \pm 4.1$  weeks in the C-only group ( $P = .13$ ). Demographic factors including age, race, and parity were similar among groups. More women in the P group had previous preterm deliveries ( $P = .001$ ). Birth weight, 1- and 5-minute Apgar scores, rates of neonatal intensive care unit admission, and hospital length of stay were similar between groups. The AUC for a model for predicting delivery <35 weeks was 0.62.

**Conclusions:** Paradoxically, a short cervix was not associated with adjunctive P therapy in women with C. The additional use of P did not prolong gestation or improve neonatal outcomes. Neither C use nor the addition of P prevented preterm birth <35 weeks.

### 2382463 Revision of a Failed Cerclage Is Associated With Higher Risk of Premature Birth Compared to Primary Cerclage

Fereshteh Boozarjomehri<sup>1</sup>, \* Margaret Dziadosz<sup>2</sup>, Morgan Peltier<sup>1</sup>, Fatima Boozarjomehri<sup>3</sup>, Anthony Vintzileos<sup>1</sup>, Ilan Timor-Tritsch<sup>2</sup>, Frederick Naftolin<sup>2</sup>

<sup>1</sup>Obstetrics and Gynecology, Winthrop University Hospital, Garden City, NY USA; <sup>2</sup>New York University School of Medicine, New York, NY USA; <sup>3</sup>Swarthmore College, Swarthmore, PA USA

**Objectives:** Little is known about pregnancy outcome of revising a failed cerclage previously placed for a sonographically short midtrimester cervix (Cx). Our previous data reported a higher risk of premature birth in patients (pts) with a revision compared with single cerclage. We aim to find if addition of 23 pts to previously reported 54 pts changes the results.

**Methods:** This is a cohort of 77 pts with Cx of <25mm, at 16–24 6/7 weeks who underwent a McDonald cerclage in 2007–2015. Nine pts required revision to correct a failed cerclage. Failed cerclage was defined as presence of a prolapsed membrane beyond the cerclage or Cx distal to cerclage of <1 cm. All cerclages were performed or supervised by 1 operator (F.B.). The gestational age at birth and other obstetric outcomes, were compared between the 2 groups.

**Results:** There were 4 pregnancy losses (2 in the 1st attempt, 2 in revision). One pt was lost to follow-up (Table 1).

**Conclusions:** Pts who need cerclage revision have higher premature birth compared to those who have successful primary cerclages. Revised cerclages were associated with a high take-home baby (7/9 or 78%) but also with a high preterm birth rate (8/9 or 89%), which should be considered when counseling pts who have failed cerclage and are candidates for revision cerclage.

Table 1

Pregnancy Outcome	1st attempt (n = 68) (1 pt Lost to Follow-up)	Revision (n = 9)	P
Gestational age at delivery, wk <sup>1</sup>	36 2/7 (4.1)	27 3/7 (6.7)	.003 <sup>a</sup>
Delivery <24 wk <sup>2</sup>	2/67 (3)	2/9 (22)	.066 <sup>b</sup>
Delivery <25 wk <sup>2</sup>	2/67 (3)	2/9 (22)	.066 <sup>b</sup>
Delivery <28 wk <sup>2</sup>	3/67 (4.5)	6/9 (66.7)	.001 <sup>b</sup>
Delivery <32 wk <sup>2</sup>	9/67 (13.4)	7/9 (77.8)	.001 <sup>b</sup>
Delivery <34 wk <sup>2</sup>	14/67 (20.9)	8/9 (88.9)	.001 <sup>b</sup>
Delivery <37 wk <sup>2</sup>	27/67 (40.3)	8/9 (88.9)	.010 <sup>b</sup>
Baby weight, g <sup>1</sup>	2830 (816)	1345 (1056)	.005 <sup>a</sup>
1-min Apgar <sup>3</sup>	8 (0.9)	7 (1.9)	.012 <sup>c</sup>
5-min Apgar <sup>3</sup>	9 (0.9)	8 (0.9)	.014 <sup>c</sup>
NICU admission <sup>2</sup>	14/63 (22)	5/7 (71.4)	.008 <sup>b</sup>
NICU days (if admitted) <sup>3</sup>	21 (6, 49)	91 (7, 154)	<.001 <sup>c</sup>

NICU indicates neonatal intensive care unit.

<sup>1</sup>Mean (SD); <sup>2</sup>proportion (%); <sup>3</sup>median (minimum, maximum).

<sup>a</sup>*t* test; <sup>b</sup>Fisher-test; <sup>c</sup>quasi-Poisson test.

### 2385068 Placental Mesenchymal Dysplasia Imitating a Partial Molar Pregnancy

David McKinney,\* Carri Warshak

Obstetrics and Gynecology, University of Cincinnati College of Medicine, Cincinnati, OH USA

**Objectives:** Case reports of placental mesenchymal dysplasia (PMD) have been published, but PMD remains incompletely understood and under-recognized by providers. We report a case of PMD detected during a routine anatomic survey.

**Methods:** A case with an omphalocele, cystic placentomegaly, fetal growth restriction (FGR), and large bilateral maternal theca lutein cysts was identified on a midtrimester ultrasound. Patient history, ultrasound findings, prenatal course, karyotype results, and pathologic findings are reported.

**Results:** A 19-year-old woman primigravida, who presented for routine ultrasound at 18 weeks' gestation. Her ultrasound revealed an omphalocele, cystic placentomegaly, FGR, and large bilateral maternal theca lutein cysts. The primary concern was for a partial molar pregnancy. Evaluation with amniocentesis for fluorescence in situ hybridization (FISH) results and karyotype and blood work for serum human chorionic gonadotropin (hCG) and thyroid studies were performed. The patient's thyrotropin and FISH results were normal, but her hCG was significantly elevated (444,862 mIU/mL). This further raised suspicion for a partial molar pregnancy until the karyotype returned as normal male (46,XY), effectively ruling out a partial mole. The differential diagnosis was then expanded to include a chorioangioma, complete molar pregnancy with a cotwin, and PMD. At 21 weeks, the patient developed severe preeclampsia. There was no role for expectant management given her gestational age and poor fetal prognosis. Induction of labor was performed, and the patient delivered a nonviable male infant. Examination of the fetus revealed an omphalocele and macroglossia. A retained placenta after delivery required a dilation and curettage to be performed. A fetal biopsy and a portion of the placenta were sent for karyotype, and both showed a normal male (46,XY) genotype. The autopsy of the fetus was consistent



with Beckwith-Wiedemann syndrome, and placental pathology was consistent with PMD. Therefore, the patient is not at risk for subsequent invasive disease, as would have been the case had the patient had a molar pregnancy.

**Conclusions:** PMD must be included in the differential diagnosis in patients with findings concerning for a partial molar pregnancy. The treatment, outcome, and complications are significantly different for these 2 conditions.

#### 2385849 Large Vascular Placental Lake on First-Trimester Ultrasound

David McKinney,\* Carri Warshak

Obstetrics and Gynecology, University of Cincinnati College of Medicine, Cincinnati, OH USA

**Objectives:** Placental sonolucencies can be the initial presentation of a wide spectrum of conditions from benign placental lakes and chorioangiomas to malignant gestational trophoblastic neoplasia (GTN). We report a case of a large vascular placental lake seen on first-trimester ultrasound that resulted in early-onset fetal growth restriction (FGR) and delivery at 34 weeks' gestation.

**Methods:** A case with a large retroplacental mass and extensive vascularity was identified on first-trimester ultrasound. Patient history, ultrasound findings, antepartum course, and placental pathology are reported.

**Results:** A 23-year-old woman multigravida, who presented for first-trimester ultrasound at 12 weeks' gestation and was found to have a large anechoic retroplacental mass that measured  $4.9 \times 5.6 \times 3.5$  cm. The mass was initially thought to be a subchorionic hemorrhage, but color Doppler imaging revealed extensive vascularity with venous-type flow throughout the fluid collection. The differential diagnosis included a placental lake, abruption, chorioangioma, or a developing GTN such as a choriocarcinoma. Serum human chorionic gonadotropin (hCG) was drawn to evaluate for GTN. Initial hCG was elevated at 391,000 mIU/mL, and a repeat the following day was 465,560 mIU/mL. This further raised concern for GTN. Workups for metastatic disease with chest computed tomography and head magnetic resonance imaging (MRI) were both negative. Pelvic MRI showed prominent vascularity but was not consistent with chorangioma or GTN. By 14 weeks' gestation, the patient's hCG was 239,390 mIU/mL. This decrease in hCG and stable size of the placental lesion provided evidence against a malignant placental condition. At 24 weeks' gestation, the mass was noted to have rapidly expanded to  $7.4 \times 9.4 \times 7.5$  cm, and the fetus was noted to have new-onset FGR that prompted an admission for administration of corticosteroids, but ultimately, induction of labor was not performed until 34 weeks secondary to worsening FGR. The patient had an uncomplicated vaginal delivery, and placental pathology revealed a partially disrupted placental disc compatible with a venous lake and no evidence of neoplasia.

**Conclusions:** Vascular placental sonolucencies can represent a variety of conditions from benign to malignant, and both conditions may have a significant impact on a pregnancy such as the FGR that developed in this case.

### Therapeutic Ultrasound

Moderator: Peter Lewin, MSc, PhD

#### 2364234 Treatment of Lower Limb Deep Vein Thrombosis by Combining Microbubble-Enhanced Ultrasound and Urokinase: A Clinical Study

Qiong Zhu<sup>1</sup>,\* Gang Dong<sup>2</sup>, Mengjiao Guo<sup>1</sup>, Shunji Gao<sup>1</sup>, Zheng Liu<sup>1</sup>, Feng Xie<sup>3</sup>

<sup>1</sup>Ultrasound, Xinqiao Hospital, Third Military Medical University, Chongqing, China; <sup>2</sup>Ultrasound, First Affiliated Hospital of Zhengzhou University, Zhengzhou, China; <sup>3</sup>Internal Medicine, Cardiology, University of Nebraska Medical Center, Omaha, NE USA

**Objectives:** The study explored catheter-directed thrombolysis (CDT) of acute lower limb deep vein thrombosis (DVT) by combining microbubble-enhanced ultrasound (MEUS) and urokinase.

**Methods:** Fourteen patients with acute DVT (<14 days) undergoing CDT consented to accept coordinated MEUS treatment as the experimental group. During the CDT process, percutaneous therapeutic ultrasound (TUS) and transcatheter injection of SonoVue microbubbles were simultaneously performed for about 40–60 minutes once a day depending on the length of the thrombus. A TUS device (SL-10 Sonolyser; Well Medical Electronics Co, Ltd, China) equipped with a single-element, nonfocused transducer was used for ultrasound thrombolysis. The transducer was operated at a frequency of 1.0 MHz with a duty factor of 0.01 and a peak negative pressure from 750 kPa to 1.0 MPa. One vial (5 mL) of SonoVue microbubbles diluted into 10 mL of saline was infused constantly into the catheter during the treatment. The other 60 acute DVT patients treated with the same CDT procedure without combining MEUS were retrospectively reviewed for the treatment days and overall urokinase dosage as the control. The criterion for terminating thrombolysis and extubation was vessel recanalization confirmed by contrast-enhanced ultrasound. Major complications such as hemorrhage were monitored. The average treatment days and overall urokinase doses of the 2 groups were compared by 1-way analysis of variance.

**Results:** The average treatment days of the experiment group ( $5.2 \pm 1.5$  days) were significantly less than those of the control ( $11.9 \pm 4.4$  days;  $P < .01$ ). Also, the overall dosage of urokinase used in the experiment group ( $391.4 \pm 165.6$  IU) dropped significantly (about 28.2%) when compared to the control group ( $545.5 \pm 247.4$  IU;  $P < .01$ ). No intracranial and local hemorrhage events happened in both groups.

**Conclusions:** By combining MEUS in CDT treatment of acute DVT, the treatment days and overall urokinase dosage were remarkably reduced. This method may help shorten the hospital stay and reduce the risk of hemorrhage.

#### 2366593 Clinical Studies of Far-Field Continuous Therapeutic Ultrasound for Enhancing Drug Delivery

Mingde Li

Ultrasonic Technique, Vancouver, BC, Canada

**Objectives:** Some infectious diseases, for example, chronic prostatitis, arthritis, nephritis, and pulpitis, are difficult to cure because of poor drug penetration. Studies indicate that ultrasonic cavitations can open the blood-brain barrier, and continuous ultrasound can enhance transdermal drug delivery at an intensity and frequency in the therapeutic range in the mechanism of cavitations. However, clinical practices for ultrasonic enhancement are limited in transdermal drug delivery. For medical devices using therapeutic ultrasound at present, an object for exposure is placed in the near field, where nonuniform ultrasonic beam distributions, also referred to as hot spots, limit the application of high ultrasonic beam; on the other hand, when the ultrasonic beam reaches the far field in the object, it diverges sharply. So these devices cannot treat diseases deep in the human body. By transmitting ultrasound with water to the far-field region where ultrasonic energy is conducted for treatment, the 2 problems can be



solved. The effectiveness of a device for far-field continuous therapeutic ultrasound designed for this mechanism is evaluated by clinical studies.

**Methods:** After each intravenous injection of antibiotics, exposure at an intensity of 1.8 W/cm<sup>2</sup> and transducer frequency of 1.7 MHz on a target region was applied immediately for 0.5 hour.

**Results:** Imipenem therapy cured a chronic prostatitis patient of Gram-positive cocci whose sexual function recovered after the treatment and failed for a patient with a similar infection treated with a fake device. Imipenem therapy improved a male ankylosing spondylitis patient who lived for more than 2 years without pain killers and failed for his brother treated with a fake device. Levofloxacin and azithromycin therapy improved reactive arthritis and cured recurrent nephritis in a female patient whose urinary protein dropped from 0.15 to 0 g/L. Levofloxacin therapy improved a male serious pulpitis patient.

**Conclusions:** Far-field continuous therapeutic ultrasound is effective for antibiotic therapies of chronic prostatitis, arthritis, nephritis, and pulpitis, and an intensity higher than 1.8 W/cm<sup>2</sup> is needed for cure of osseous infections.

### 2378893 Ultrasound-Enhanced Neoadjuvant Chemotherapy of Cervical Carcinoma Combined With Microbubbles and Hydrogen Peroxide

Xueyan Qiao<sup>1</sup>, \* Yan Zhu<sup>2</sup>, Xi Xiong<sup>2</sup>, Ping Yan<sup>2</sup>, Zheng Liu<sup>1</sup>

<sup>1</sup>Ultrasound, <sup>2</sup>Obstetrics and Gynecology, Xinqiao Hospital, Third Military Medical University, Chongqing, China

**Objectives:** The study is aimed to enhance neoadjuvant chemotherapy of cervical carcinoma by combining diagnostic ultrasound (US), microbubbles (MBs), and hydrogen peroxide.

**Methods:** Seven patients with cervical carcinoma (aged 33–72 years, International Federation of Gynecology and Obstetrics stage IIa–IIb) who were eligible to receive neoadjuvant chemotherapy (nedaplatin and paclitaxel) before hysterectomy consented to the combination therapy. Another 29 patients with neoadjuvant chemotherapy alone served as the control. For the combination therapy, the cervical lesions were exposed to transvaginal US (Philips iU22) at the peak plasma concentration of chemotherapy for 15–20 minutes. Two US settings were selected for exposure. Flash mode was applied to 5 cases with a mechanical index (MI) of 0.77 and B-mode for another 2 cases with an MI of 0.4. During US exposure, 5 mL of SonoVue MBs was infused, and the vagina was persistently rinsed with 100 mL of 3% hydrogen peroxide. Each patient received ultrasound treatment 2 or 4 times. All patients underwent hysterectomy 3 weeks after chemotherapy. In histologic examination, a semiquantitative score was used to describe the tumor invasion: 0, no cancer remained; 1, invasion of less than half of the muscular layer; or 2, invasion deeper than half of the muscular layer.

**Results:** Most of the cervical lesions showed a decrease in blood perfusion in the central area and slight perfusion enhancement at the margin after being treated by flash mode. However, the lesion perfusion was overall significantly enhanced in the other 2 cases treated by B-mode. As shown in Table 1, the cancer-free rate in the patients treated with the combination therapy had an increasing trend when compared with the control ( $P = .06$ ).

**Conclusions:** Diagnostic US combined with MBs and hydrogen peroxide can change the blood perfusion of cervical carcinoma, which was understood as vascular effects of cavitation. These effects tended to improve the cancer-free rate in the chemotherapy.

Table 1. Semiquantitative Scores of Pathologic Results

Scoring	0, n (%)	1, n (%)	2, n (%)
Combination	3 (42.8)	1 (14)	3 (42.8)
Chemotherapy alone	3 (10.3)	9 (31)	17 (58)

### 2381296 Restoration of the Blood-Brain Barrier Following Ultrasound-Induced Opening Appears to Be Independent of Opening Volume

Meaghan O'Reilly<sup>1,2</sup>, \* Olivia Hough<sup>1</sup>, Kullervo Hynynen<sup>1,2,3</sup>

<sup>1</sup>Sunnybrook Research Institute, Toronto, ON, Canada;

<sup>2</sup>Medical Biophysics, <sup>3</sup>Institute of Biomaterials and Biomedical Engineering, University of Toronto, Toronto, ON, Canada

**Objectives:** Preclinical studies have shown promising results for the use of focused ultrasound (FUS) opening of the blood-brain barrier (BBB) in the treatment of brain diseases, including tumors and Alzheimer's disease. Some studies have reported significantly longer times (>24 hours) to BBB closure following FUS when higher pressures, and consequently larger volumes, are opened and have related closure time to the size of the opening. Clinical implementation of this method, particularly for some conditions, may require large treatment volumes. Thus, the relationship between opening volume and closure time merits further investigation. The purpose of this study was to test the hypothesis that controlled BBB opening with overlapping focal spots will result in a closure time that is independent of the disrupted volume.

**Methods:** Sprague Dawley rats ( $n = 5$ ;  $\approx 300$  g) were used in this study. Sonications (551.5 kHz; 10-millisecond burst; 1-Hz pulse repetition frequency; 2-minute duration; Tx FN = 0.8; diameter = 75 mm) were performed using magnetic resonance imaging (MRI) targeting (7 T), beginning simultaneously with the start of an intravenous injection of Definity microbubbles (MBs; 0.02 mL/kg). MB emissions were detected by a wideband receiver and used to actively control the sonication pressures during the treatments (O'Reilly and Hynynen, *Radiology* 2012). Each animal was treated in 1 hemisphere with a single point and a 4-point overlapping grid in the contralateral hemisphere. Contrast-enhanced T1-weighted MRI was used to assess the integrity of the BBB at  $t = 0, 6$ , and 24 hours.

**Results:** There was no significant difference immediately following FUS ( $t = 0$ ) in the mean enhancement between the 2 hemispheres ( $30\% \pm 18\%$  vs  $30\% \pm 24\%$ ; paired  $t$  test:  $P = .9975$ ). The mean opening cross-sectional area of the 4-point sonication was  $\approx 3.5$  times larger than the 1-point sonication ( $14.2 \pm 4.7$  vs  $4.1 \pm 3.3$  mm<sup>2</sup>). Only 1 hemisphere remained open at 6 hours and was fully closed by 24 hours. T2-weighted fast spin and gradient echo images at 6 and 24 hours showed no signs of edema or hemorrhage.

**Conclusions:** The time for the BBB to be restored appears to be independent of opening volume on the time scale investigated. With other studies examining the safety of FUS BBB opening, this study supports the conclusion that FUS BBB opening would be safe at a clinical scale.

### 2383984 Effects of In Vivo Ultrasonic Exposure to the Rat Heart: Reproducibility of Heart Rate and Cardiac Output Depression

Olivia Coiado<sup>1</sup>, \* William O'Brien Jr<sup>2</sup>

<sup>1</sup>Donald. P. Shiley School of Engineering, University of Portland, Portland, OR USA; <sup>2</sup>Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, Urbana, IL USA

**Objectives:** An important aspect of therapeutic ultrasound is its ability to produce a controlled biological effect noninvasively. The aim of this study was to investigate the reproducibility of an in vivo cardiac effect using a sequence of ultrasonic pulses and decreasing pulse repetition frequencies (PRFs).

**Methods:** Two independently conducted studies were evaluated, each using 3-month-old 200- to 250-g Sprague Dawley rats. Study 1: Experimental (US1) and sham control (CTR1) groups used 10 and 5 rats, respectively. Study 2: Experimental (US2) and sham control (CTR2) groups each used 5 rats. Each study used a different 1-MHz, 25-mm-

diameter transducer. The protocol was the same for both studies: 1-MHz pulses,  $\approx 1\%$  duty factor with 3 sequences of 2.0, 2.5, and 3.0 MPa peak rarefactional pressure amplitude (PRPA) pulses and with variable PRFs every 10 seconds (ie, 6, 5, and 4 Hz for a total duration of 30 seconds) in each sequence. The total ultrasound exposure duration was 90 seconds. Cardiac conditions were evaluated before (at baseline) and at 3 and 15 minutes after ultrasonic exposure ceased.

**Results:** Heart rate (HR) and cardiac output (CO) groups are shown in Table 1. Post-3- and 15-minute decreases for HR and CO show the same trends and about the same values when US1-US2 are compared and CRT1-CRT2 are compared. For example, CO after 3 and 15 minutes for US1 and US2 decreases are, respectively, 15%–18% and 16%–19%.

**Conclusions:** These results raise the possibility of circulatory depression resulting from therapeutic ultrasonic stimulation and stress the need of additional studies to elucidate not only the physiologic mechanisms involved in the production of these effects but also the potential risks of the clinical use of ultrasound application to the thorax. (Supported by National Institutes of Health grant R37EB002641.)

Table 1

Parameter	US1 (n = 10)	CTR1 (n = 5)	US2 (n = 5)	CTR2 (n = 5)
HR at baseline, beats/min	345 $\pm$ 8	353 $\pm$ 8	323 $\pm$ 13	349 $\pm$ 12
HR post 3 min, %	–19.7 $\pm$ 6.0	–0.98 $\pm$ 1.59	–7.29 $\pm$ 2.28	–0.79 $\pm$ 1.70
HR post 15 min, %	–24.8 $\pm$ 7.0	–5.14 $\pm$ 3.15	–12.5 $\pm$ 0.33	–7.30 $\pm$ 1.26
CO at baseline, mL/min	49.6 $\pm$ 2.0	56.7 $\pm$ 3.2	59.4 $\pm$ 4.4	51.3 $\pm$ 1.4
CO post 3 min, %	–14.9 $\pm$ 11.5	–3.18 $\pm$ 0.90	–16.1 $\pm$ 5.63	–0.73 $\pm$ 0.03
CO post 15 min, %	–18.7 $\pm$ 5.5	–6.48 $\pm$ 6.75	–19.0 $\pm$ 3.36	–11.21 $\pm$ 0.27

#### 2384123 A Novel Tikhonov Regularization Scheme to Focus Ultrasound Phased Arrays

*Alec Hughes,\* Kullervo Hynynen*

*Medical Biophysics, University of Toronto, Toronto, ON, Canada; Physical Sciences Platform, Sunnybrook Research Institute, Toronto, ON, Canada*

**Objectives:** Conventional focusing of phased array ultrasonics involves the use of phase delays to obtain a pressure maximum at the desired focus location; that is, the desired focus is considered an infinitesimal point in space. This allows for beam steering, as well as tight focusing through even highly heterogeneous media. In reality, the focus manifests as an elongated distribution of pressure, which can be studied using contours of pressure, or in the case of focused ultrasound for hyperthermia, temperature, and thermal dose. Here, a novel method of focusing a phased array using a modified Tikhonov regularization scheme is introduced, so that the spatial orientation of the focus is controlled.

**Methods:** Tikhonov regularization is used to solve ill-posed inverse problems. Here, a modified Tikhonov regularization is used to perform spatial isometries on a focus. By sampling points away from the target focus location, it is possible to solve the inverse problem for the phased array controls to freely control the spatial manifestation of the focus. Numerical simulations demonstrate the implementation of these novel controls to a planar phased array.

**Results:** It is shown that given a sufficient number of elements in the array, it is possible to freely rotate and steer a focus through space using this focusing method. It is found that the modified Tikhonov regularization parameter, which will be called  $\alpha$ , allows for the balance be-

tween the peak intensity of the focus, the spatial orientation of the focus, and the even distribution of power among the elements in the array. Future applications and limitations of this method are then discussed.

**Conclusions:** Conventional focusing of ultrasound phased arrays considers the target location as an infinitesimal point in space. We argue that there are benefits to considering the spatial shape of the focus and its orientation. A novel technique for focusing ultrasound phased arrays is introduced.

#### 2385368 First-in-Human Clinical Trial Using Ultrasonic Propulsion to Reposition Renal Calculi in Humans

*Jeff Thiel<sup>1,2,\*</sup>, Jonathan Harper<sup>3</sup>, Franklin Lee<sup>3</sup>, Bryan Cunitz<sup>2</sup>, Barbrina Dunmire<sup>2</sup>, Michael Bailey<sup>2</sup>, Manjiri Dighe<sup>1</sup>, Mathew Sorensen<sup>3,4</sup>*

*<sup>1</sup>Radiology, <sup>2</sup>Applied Physics Lab, <sup>3</sup>Urology, University of Washington, Seattle, WA USA; <sup>4</sup>Urology, Department of Veterans Affairs, Seattle, WA USA*

**Objectives:** Ultrasonic propulsion is a new technology developed to facilitate the natural passage of stones transcutaneously.

**Methods:** Fifteen subjects were treated with the investigational device, either awake or under anesthesia. Nine subjects had de novo stones (2–10 mm), and 6 subjects were postlithotripsy (<2-mm fragments). The research device consisted of a software-based ultrasound system and C5-2 imaging probe. The same probe was used for imaging and for propulsion. Stone movement was monitored in real time using B-mode imaging. Effectiveness was evaluated by the number of stones moved and stone passage. Safety was evaluated by completion of a pain questionnaire before and after the investigational treatment and verbal follow-up for 3 weeks following treatment.

**Results:** Stone movement was achieved in 14 of 15 subjects, including 43 targets. Four of the 6 lithotripsy subjects reported passing in total more than 30 stone fragments within a few days following treatment. One subject passed 2 fragments before leaving the clinic. All awake subjects reported minor warming of the skin from probe surface heating associated with the longer-duration ultrasonic propulsion pulse. Two subjects reported a minor sensation deep within the kidney, on a couple occasions; neither indicated wanting to stop the treatment. No treatment-associated adverse events were reported by the subjects outside the normal experience of having kidney stones. In 4 subjects, calculi identified on ultrasound as being 1 large stone were shown to be multiple small fragments.

**Conclusions:** Ultrasonic propulsion has been shown to safely and effectively reposition renal calculi in humans and facilitate stone passage. In addition to the therapeutic benefit, ultrasonic propulsion proved to be diagnostic in cases where multiple fragments appeared as 1 large stone. This could be extended to aid confidence in the detection of kidney stones with ultrasound. Research is continuing to improve efficiency in clearing large groups of fragments and also relieving acute pain caused by obstructing stones. (Support provided by the National Space and Biomedical Research Institute through NASA NCC 9-58 and National Institutes of Health National Institute of Diabetes and Digestive and Kidney Diseases grants DK043881 and DK092197.)

#### 2393124 Therapeutic Ultrasound for Stimulation of Insulin Release as a Potential Treatment for Type 2 Diabetes

*Ivan Suarez<sup>1</sup>, Aleksandar Jeremic<sup>2</sup>, Vesna Zderic<sup>1,\*</sup>*

*<sup>1</sup>Biomedical, <sup>2</sup>Biological Sciences, George Washington University, Washington, DC USA*

**Objectives:** Type 2 diabetes mellitus is a complex metabolic disease that has reached epidemic proportions. The objective of this study is to explore a novel, nonpharmacologic approach that utilizes the application of ultrasound energy to augment insulin release from pancreatic  $\beta$  cells.

**Methods:** Our experiments focus on determination of the effectiveness and safety of ultrasound application in stimulation of insulin

release from pancreatic  $\beta$  cells. An insulin release enzyme-linked immunosorbent assay (ELISA) was used to determine and quantify the effects of ultrasound on insulin release in cultured INS-1  $\beta$  cells. Effects of ultrasound on cell viability were assessed by the trypan blue exclusion method. Planar ultrasound transducers with center frequencies of 400 kHz, 600 kHz, 800 kHz, and 1 MHz were used to expose cells for a duration of 5 minutes at an intensity of 1 W/cm<sup>2</sup>.

**Results:** Our results indicated that cell viability was not significantly affected during and for up to 30 minutes after treatment when cells were exposed to ultrasound frequencies of 800 kHz and 1 MHz. However, cell viability was highly reduced (by  $\approx 80\%$ – $90\%$ ) when the cells were exposed to ultrasound frequencies of 400 and 600 kHz ( $P < .001$ ). ELISA results showed that significant amounts of insulin were released from  $\beta$  cells exposed to 400- and 600-kHz ultrasound at the cost of cell viability ( $P < .05$ ). Cell exposure to ultrasound at a frequency of 800 kHz resulted in an approximately 4-fold increase in insulin release ( $P < .005$ ). Cell exposure to ultrasound at a frequency of 1 MHz also showed increased insulin release ( $\approx 50\%$ ), although no statistical significance was achieved when compared to sham treatment.

**Conclusions:** If shown to be successful, our approach may eventually lead to new methods in the treatment of diabetes and other secretory diseases. Our future studies will focus on application of ultrasound to human pancreatic islets to determine whether it would be possible to stimulate  $\beta$  cells without stimulating other endocrine and exocrine cells of the pancreas.

#### 2393141 Amperometric Detection of Ultrasound-Induced Secretory Events From Pancreatic $\beta$ Cells

*Bogdan Balteanu<sup>1</sup>, Tania Singh<sup>1</sup>, Ivan Suarez<sup>1</sup>, Aleksandar Jeremic<sup>2</sup>, Vesna Zderic<sup>1\*</sup>*

<sup>1</sup>Biomedical, <sup>2</sup>Biological Sciences, George Washington University, Washington, DC USA

**Objectives:** The objective of this study was to explore a potential new treatment method that utilizes a noninvasive application of ultrasound energy to induce exocytosis of insulin from pancreatic  $\beta$  cells. Our amperometric measurements can not only provide confirmation of secretion but also data that could lead to optimization in controlling the release via ultrasound application.

**Methods:** Our experiments focused on detecting exocytotic secretions from pancreatic  $\beta$  cells in response to ultrasound stimulation using carbon fiber amperometry. Exocytosis of insulin is measured via amperometric readings of the oxidation of dopamine. Dopamine that is loaded into cells is released via vesicles along with insulin. Results were obtained with commercially available electrodes as well as electrodes fabricated in-house. A sham group was included in which cells were loaded with dopamine but not stimulated for secretion.

**Results:** To confirm the functionality of the in-house-made electrodes, a triangular waveform was run through the electrode, and using an oscilloscope, the original signal was compared to the one from the electrode. The test was run repeatedly with different parameters to ensure accurate measurements from the electrode. The ultrasound pulse was applied 3 times ( $t = 30, 90,$  and  $150$  seconds). Amperometric spikes were seen starting at  $t = 250$  seconds, although the highest peak was observed at  $t = 325$  seconds. The delay between the point of stimulation and the amperometric spikes can be attributed to the diffusion time of dopamine from the stimulated cell to the tip of the microelectrode. Meanwhile, the cells belonging to the sham group did not exhibit any amperometric response. The preliminary results confirm that ultrasound stimulation induces secretion in  $\beta$  cells. Ongoing experiments focus on exploring the impact of varying parameters such as ultrasound frequency, intensity, and pulse length on exocytosis.

**Conclusions:** Our proposed technology could directly target one of the underlying causes of insulin deficiency in type 2 diabetes and could result in the development of new therapeutic approaches in the treatment of this disease.



**SCIENTIFIC SESSIONS**  
**SUNDAY, MARCH 20, 2016, 11:00 AM–12:30 PM**

**Basic Science: Tissue Characterization**

*Moderator: Katherine Nightingale, MD*

**2378080 Limitations of the Kramers-Kronig Approximations for Ultrasound Propagation in Soft and Hard Tissue**

**James Miller,\* Jonathan Katz**

*Physics, Washington University, St Louis, MO USA*

**Objectives:** This study examines, in the context of future applications of ultrasonic tissue characterization, the validity of specific approximations to the causality-imposed Kramers-Kronig (KK) relations.

**Methods:** Attenuation was determined using log spectral subtraction. Phase velocity was obtained using phase spectroscopy.

**Results:** Data from wide ranges of samples of heart, cancellous bone, and tissue-mimicking materials exhibited an approximately linear increase of the attenuation coefficient with frequency. A “nearly local” KK approximation then predicted dispersions that increased logarithmically with frequency, in good agreement with experimental data for most substances but with significant deviations for others.

**Conclusions:** For a given type of material, lower sound speeds are generally accompanied by higher attenuations, although no quantitative “completely local” link between the speed of sound at a given frequency and the attenuation coefficient at that frequency is known. Although the exact KK relations involve properties from zero to infinite frequency, experimental data are usually processed with some type of a “finite bandwidth” approximation. An extreme case is the “nearly local” KK relations, in which the attenuation coefficient at a specific frequency is related to the frequency derivative of the phase velocity at that single frequency. Surprisingly, the “nearly local” KK relations are remarkably accurate in most cases of interest. However, data from this study and from other laboratories contain instances in which not only the magnitude but even the sign of the predicted dispersion differs from that measured. Effects arising from the tails of strong responses outside of the experimental frequency range (analogous to optical dispersion at visible wavelengths produced by UV absorptivity), phase aberration, and the presence of multiple modes (eg, fast and slow compressional modes) can yield significant deviations. (Contributions by many previous members of our laboratory will be acknowledged in the presentation.)

**2373262 Coronary Artery Disease Risk Stratification Using Feature Strength in a Machine-Learning Paradigm: A Link Between Coronary and Carotid Ultrasound Plaque Burdens**

**Tadashi Araki<sup>2</sup>, Nobutaka Ikeda<sup>3</sup>, Devarshi Shukla<sup>4</sup>, Narendra Londhe<sup>4</sup>, Vimal Shrivastava<sup>4</sup>, Sumit Banthor<sup>4</sup>, Luca Saba<sup>5</sup>, Andrew Nicolaidis<sup>6</sup>, Shoaib Shafique<sup>7</sup>, John Laird<sup>8</sup>, Jasjit Suri<sup>1</sup>**

<sup>1</sup>Electrical Engineering, University of Idaho (Affiliate), Pocatello, ID USA; <sup>2</sup>Electrical Engineering, AtheroPoint, LLC, Roseville, CA USA; <sup>3</sup>Division of Cardiovascular Medicine, Toho University Ohashi Medical Center, Tokyo, Japan; <sup>4</sup>Cardiovascular Medicine, National Center for Global Health and Medicine, Tokyo, Japan; <sup>5</sup>Electrical Engineering, NIT Raipur, Raipur, Chhattisgarh, India; <sup>6</sup>Azienda Ospedaliero Universitaria di Cagliari—Polo di Monserrato, Università di Cagliari, Monserrato, Italy; <sup>7</sup>Vascular Screening and Diagnostic Center, London, England, Biological Sciences University of Cyprus, Nicosia, Cyprus; <sup>8</sup>CorVasc Vascular Laboratory, Indianapolis, IN USA; <sup>8</sup>UC Davis Vascular Center, University of California, Davis, CA USA

**Objectives:** During the screening procedure prior to stenting and intravascular ultrasound (IVUS)-based percutaneous coronary inter-

vention procedures, interventional cardiologists are keen in risk stratification of coronary artery disease (CAD) for myocardial infarction. Further, it helps to prevent an excessive cost burden and better cardiovascular disease management. Current methods do not employ plaque morphology-based characteristics for risk assessment. This study for the first time employs the combination of carotid US and IVUS to stratify the risk of CAD for myocardial infarction.

**Methods:** Institutional Review Board–approved coronary IVUS and carotid B-mode US were jointly collected on 15 patients via: (1) a 40-MHz catheter utilizing iMap (Boston Scientific, Marlborough, MA) with 2865 frames per patient; and (2) linear probe B-mode carotid US (Toshiba, Tokyo, Japan). This study presents a strategy for coronary risk assessment by combining the IVUS grayscale plaque morphology and carotid B-mode US stroke biomarker intima-media thickness. A machine-learning paradigm is adapted for risk stratification. Both learning and training phases use tissue characteristics derived from 56 novel grayscale features, which are then used by the support vector machine (SVM) classifier. The dominant features are then selected based on the feature strengths by arranging in ascending/descending order. A K-fold cross-validation protocol with 10 trials per fold is used for cross-validation and performance evaluation.

**Results:** Polynomial order 2 kernel function in the SVM-based classifier achieved an accuracy of 94.95% with an area under the curve of 0.95. The machine-learning system showed consistency in reliability and stability with an increase in data sets.

**Conclusions:** The machine-learning system based on dominant feature extraction utilizing the strengths of the features was successfully used for CAD risk stratification. Coronary grayscale plaque morphology was combined with carotid plaque in a machine-learning protocol for training/testing phases of the system. The system showed high accuracy, demonstrating its reliability. The CADx system showed encouraging results and can be adapted in clinical settings.

**2382475 Does Soft Tissue Vascularity Influence Elasticity?**

**Kevin Parker**

*Electrical and Computer Engineering, University of Rochester, Rochester, NY USA*

**Objectives:** To assess the effects of changes in vascularity on the biomechanics response of soft tissues, using experimental and theoretical approaches.

**Methods:** Experimental tests of the microchannel flow model (MFM) were made on liver samples where changes in salinity (and therefore cellular swelling, which restricts small channels) were found to change the stress-relaxation curves. Cylindrical cores (approximately 25 mm in diameter and 60 mm in length) were acquired from fresh bovine livers using a custom-made coring tool and stored at 4°C for 24 hours in either hypotonic (0.65%) saline, normal (0.9%) saline, or hypertonic (1.15%) saline. The osmotic pressure difference can cause swelling or shrinking.

**Results:** The result shows that the 4-parameter MFM provides us with a closer curve fit for the beef liver tissues compared to the Kelvin-Voigt Fractional Derivative model. In the 4-parameter model parameters, the amplitude A has a distinct trend as its value is decreasing from 0.65% saline (highest, 4.1 kPa) to 1.15% saline (lowest, 1.4 kPa). The power law parameter was in the range of 0.11–0.14 for all samples. Similar results were obtained in other soft tissues.

**Conclusions:** The MFM predicts a number of ways in which a sample of normal soft tissue such as liver can be modified so as to be perceived as less compliant, or hardened. First, an increase in E may, for example, be achieved by soaking the specimens in formalin, which is known to harden and preserve samples. A second way to harden a sample is by increasing the viscosity of the fluids in the microchannels (Parker, 2015). Finally, and even less obvious, is the hardening caused by constriction of the smallest microchannels. This has a double effect in modifying the re-



laxation spectrum and shifting it to the right (longer time constants) according to the theory of the MFM (Parker, 2015). The net result is a modification that makes the specimen feel more resistant, or harder, over long time intervals. This was experimentally approximated with swelling from hypotonic saline; however, in vivo, this could be the net effect of inflammatory responses or edema. This could explain, for example, why inflamed regions of skin feel harder than the surrounding normal tissue.

**2385301 Acquiring Maps of Attenuation Slope During Thermal Ablation of Ex Vivo Bovine Liver**  
**Kayvan Samimi,\* Tomy Varghese**  
*Medical Physics, University of Wisconsin, Madison, WI USA*

**Objectives:** Evaluate feasibility of monitoring thermal ablation of liver using real-time maps of the slope of the attenuation parameter overlaid on B-mode images of the ablation site.

**Methods:** We performed 10 microwave ablation procedures (Certus 140; NeuWave Medical) on ex vivo bovine liver. Ablations were monitored using an ultrasound research scanner (SonixTouch; Analogic) equipped with a linear array transducer (L14-5), with radiofrequency (RF) data acquired in real time. Fiber-optic temperature sensors (Neoptix Canada) were inserted into the ablation zone to record tissue temperature changes. A well-characterized uniform tissue-mimicking phantom was also scanned using the same scanner settings. RF data were downloaded and processed offline using the spectral difference reference phantom method (RPM) and the spectral shift hybrid method. Attenuation slope maps were formed at 1-second intervals and overlaid on their corresponding B-mode frames to create a series of augmented images, monitoring the procedure before, during, and after completion of microwave ablation.

**Results:** The ablation zone presents with an increase in the slope of attenuation. A good correlation between the shape and size of the ablation zone in the attenuation maps and in the pathologic images of the ablated liver was observed. Known issues with spectral difference methods, such as presence of negative attenuation estimates near backscatter change boundaries, are also noted in the results. Reduction in these artifacts is shown using an improved hybrid algorithm.

**Conclusions:** Attenuation slope is a quantitative ultrasound parameter that can monitor the progression of ablation during minimally invasive therapeutic procedures. Conventional methods of attenuation estimation using clinical scanners, including the spectral difference RPM, are not sufficiently accurate for clinical use. Improving attenuation estimation techniques is an important area of research and one of the focus areas of our group. (Supported in part by National Institutes of Health grants R01 CA112192, and T32 CA09206-36A1.)

**2385314 In Vivo Acoustic Radiation Force Impulse Characterization of Human Carotid Atherosclerotic Plaque Composition and Structure**

**Tomasz Czernuszewicz<sup>1</sup>, Jonathon Homeister<sup>3,2,3</sup>, Melissa Caughey<sup>4</sup>, Mark Farber<sup>5</sup>, Joseph Fulton<sup>5</sup>, Peter Ford<sup>5</sup>, William Marston<sup>5</sup>, Raghuvver Vallabhaneni<sup>5</sup>, Timothy Nichols<sup>3,4</sup>, Caterina Gallippi<sup>1,2,6\*</sup>**

<sup>1</sup>Joint Department of Biomedical Engineering, University of North Carolina and North Carolina State University, Chapel Hill, NC USA; <sup>2</sup>McAllister Heart Institute, <sup>3</sup>Pathology and Laboratory Medicine, <sup>4</sup>Medicine, <sup>5</sup>Surgery, <sup>6</sup>Biomedical Research Imaging Center, University of North Carolina, Chapel Hill, NC USA

**Objectives:** It has been shown that carotid plaques composed of large, mechanically soft necrotic cores covered by thin fibrous caps have a propensity to rupture and induce cerebrovascular accidents. To improve plaque characterization with ultrasound, our group has been investigating acoustic radiation force impulse (ARFI) imaging, which has shown promise in early animal and human studies. We herein report results

for in vivo carotid ARFI imaging with matched histology and trained reader assessments in patients undergoing endarterectomy.

**Methods:** Patients were consented and recruited from University of North Carolina Hospitals and imaged with ARFI on a Siemens Acuson Antares. Imaging was performed preoperatively by focusing on the surgical plaque. After surgery, the extracted specimen was imaged with micro computed tomography, decalcified, and sectioned according to noted arterial geometry for spatial registration to the ultrasound imaging plane. The sections were stained with hematoxylin-eosin, combined Masson's elastin (CME), and Von Kossa. ARFI peak displacement images were assessed by 6 trained readers, who identified the lipid/necrotic core, intraplaque hemorrhage, fibrous cap, calcium deposit, and collagen deposition within the ARFI plaque images. Reader assessments were compared to the matched histology.

**Results:** From 25 patients, 20 intact plaque samples were collected with matched ARFI images. In a 45-year-old symptomatic female, the ARFI image shows a focal stenosis with plaque in the proximal wall. The plaque appears to displace far ( $10.8 \pm 11.7 \mu\text{m}$ ) and is covered by a low-displacing region ( $2.8 \pm 0.9 \mu\text{m}$ ,  $0.93 \pm 0.4 \text{ mm}$  thick), suggesting a necrotic core and fibrous cap that was confirmed by histology (with cap thickness of  $0.91 \pm 0.1 \text{ mm}$ ). Readers properly identified the high-displacing ARFI region as corresponding to the location and size of the necrotic core and the low-displacing region as corresponding to the location and thickness of the fibrous cap. Out of the 20 plaque samples, 13 were ruptured with significant hemorrhage, and 9 were correctly identified by the best-performing reader.

**Conclusions:** These results suggest that ARFI is relevant to characterizing plaque composition and structure via mechanical stiffness, which may improve plaque risk stratification.

## Breast Ultrasound

**Moderator: Gary Whitman, MD**

**2385255 New York State Breast Density Mandate: Follow-up Data of Screening Ultrasound and Breast Cancer Detection**  
**Stamatia Destounis**

*Elizabeth Wende Breast Care, LLC, Rochester, NY USA*

**Objectives:** To determine the impact of screening breast ultrasound (US) in women with mammographically dense breasts on breast cancer detection.

**Methods:** This study utilized a retrospective chart review. Data collected included: total number of screening mammograms; total number of dense breast screening US exams performed; total number of procedures performed; biopsy results; and demographic data on those with cancer diagnosis. Data were obtained from the time period of 6/1/2014 through 8/31/2015.

**Results:** In this time period, there were a total of 93,817 screening mammograms performed at our facility. Of these, 36,341 patients were informed that their breast tissue was heterogeneously dense or extremely dense (39%), with 4900 screening US exams performed in 4785 patients. We reviewed the outcomes of the screening US exams performed in this population. There were 51 biopsies/procedures (1.0%) performed based on the screening US exam, with 12 cancers and 1 atypical lesion diagnosed. Cancers detected were all invasive. Average lesion size at excision was 1.4 cm, and all were node negative. One patient did not have surgery due to extensive metastatic disease. This study found a positive predictive value (PPV) of 24% (12/51) and 99% specificity (4849/4900), with cancer detection of 2.5 cancers per 1000.

**Conclusions:** The results review the second year of our screening program with screening US and identify that screening breast US in women with dense breast tissue can detect otherwise occult malignancy with a low recall rate and a reasonable PPV for biopsy.

**2385774 Characterizing Breast Microcalcifications Using a New Ultrasound Image-Processing Technique**

**Priscilla Machado,\* Maria Stanczak, John Eisenbrey, Barbara Cavanaugh, Lisa Zorn, Flemming Forsberg**  
Radiology, Thomas Jefferson University, Philadelphia, PA USA

**Objectives:** To evaluate a new commercial image-processing technique (MicroPure; Toshiba America Medical Systems, Tustin, CA) for the characterization of breast microcalcifications in patients undergoing stereotactic or ultrasound (US)-guided biopsies.

**Methods:** One hundred women scheduled for stereotactic or US-guided biopsy of an area with breast calcifications (almost always without an associated mass) provided informed consent to participate in the study. Patients underwent real-time dual imaging of grayscale US and MicroPure using an Aplio XG scanner (Toshiba). MicroPure combines nonlinear imaging and speckle suppression to mark suspected calcifications as white spots in a blue overlay image. Four independent and blinded readers (2 radiologists and 2 physicists) analyzed 208 digital clips to determine the number of calcifications seen with MicroPure and also to provide a subjective view on the level of suspicion (LOS) on a 5-point scale (benign to malignant). Mammograms of the subjects were analyzed by a radiologist who counted the exact number of microcalcifications. The number of microcalcifications was compared by reader and on average with the mammographic numbers. The LOS was compared to pathology using receiver operating characteristic (ROC) analysis.

**Results:** The mean number of microcalcifications seen on MicroPure was  $5.9 \pm 4.2$  (range, 0–22). These values were significantly lower than the number of microcalcifications identified on mammography ( $42.6 \pm 51.5$ ;  $P < .001$ ), which is similar to our prior study (Machado et al, *J Ultrasound Med* 2012). ROC analysis of readers' LOS scores produced areas under the curve of 0.54–0.59. However, the number of microcalcifications seen with MicroPure was significantly higher in malignant than benign cases ( $6.8 \pm 5.1$  vs  $5.3 \pm 3.7$ ;  $P = .021$ ) with the radiologists showing a better agreement with the pathology findings than the physicists. No such difference was found for mammography ( $P > .15$ ).

**Conclusions:** MicroPure was able to identify breast microcalcifications and correctly characterize a target area based on the number of calcifications seen. The accuracy of the ROC curves was quite low, indicating that the visual appearance of microcalcifications is not as important.

**2385746 Breast Ultrasound Tomography: A Clinical Study**

**Lianjie Huang,\* Junseob Shin, Youzuo Lin, Ting Chen, Kai Gao, Kenneth Hanson**  
Los Alamos National Laboratory, Los Alamos, NM USA

**Objectives:** Breast ultrasound tomography is a new imaging modality for breast cancer detection and characterization. It could become a safe (nonionizing), comfortable (no compression), cost-effective, and operator-independent imaging modality if its clinical capability is proved. The objective of this study is to study the clinical feasibility of breast ultrasound tomography for breast cancer imaging and characterization.

**Methods:** We have designed and manufactured a cutting-edge breast ultrasound tomography prototype with 2 parallel transducer arrays and a ring transducer array for the clinical study. The distance of these 2 arrays is adjustable for scanning different sizes of the breast. The transducer arrays are translated vertically to scan the entire breast from the chest wall to the nipple region. The scanning process is controlled by a computer and thus is operator independent. It takes approximately 2–4 minutes to scan the entire breast. We have used the system to acquire in vivo patient data at the University of New Mexico Hospital and reconstructed breast images using our recently developed high-resolution ultrasound tomography algorithms.

**Results:** We have compared our ultrasound tomography images with mammograms and clinical ultrasound images. Our breast ultrasound tomography images show lesions seen on mammograms. For 2 of

the 28 patients scanned, our ultrasound tomography images reveals lesions that are not seen on mammograms.

**Conclusions:** We have designed and manufactured a novel breast ultrasound tomography prototype capable of scanning the whole breast in 2–4 minutes. We have used the prototype to acquire in vivo patient data, and our clinical images not only show lesions seen on mammograms but also reveal lesions that are not detectable using mammography. This preliminary study demonstrates the great potential of ultrasound tomography for breast cancer detection and characterization.

**2384877 Fusion of Computed Tomographic (CT) and Sonographic Images for Breast Cancer Evaluation Using Real-time Virtual Sonography With CT Navigation**

**Tsun-Hou Chang,\* Hsian-He Hsu**

Radiology, Tri-Service General Hospital, Taipei, Taiwan

**Objectives:** We recently developed a real-time virtual sonography (RVS) system that enables simultaneous display of both sonographic and computed tomographic (CT) cutaway images of the same site in real time. The aim of this study was to evaluate the role of RVS in the management of suspicious lesions visualized with CT.

**Methods:** Between December 2014 and April 2015, 5 patients underwent CT for staging of known breast cancer going to neoadjuvant chemotherapy, postmastectomy regular follow-up, or incidental abnormal findings on CT under some clinical purposes at our hospital. All patients were examined using ultrasonography (US), CT, and RVS before biopsy for tissue proof if indicated. Results were correlated with histopathologic findings. CT was obtained on a multidetector CT imager (64/256), with the patient in the supine position. Diagnostic accuracy was compared with or without RVS.

**Results:** Suspicious lesions on CT or US can be identified under the RVS system. Diagnostic accuracy depends on good landmarks of chest anatomy for multistep registration. It is necessary to perform RVS over the breast or axillary region with soft maneuvers. More practice could increase diagnostic accuracy.

**Conclusions:** Our results suggest that the RVS system can help those whose lesions are not clearly seen on US but suspicious looking on CT, to localize it on the US. If indicated for tissue proof, it is also convenient to do sonographically guided core biopsy under RVS with navigation.

**2381756 Subharmonic Pressure Estimation in Breast Tumors: Calibration and Treatment**

**Valgerdur Halldorsdottir<sup>1,2,\*</sup>, Jaydev Dave<sup>1</sup>, Andrew Marshall<sup>1,2</sup>, Anya Forsberg<sup>3,4</sup>, Priscilla Machado<sup>1</sup>, Traci Fox<sup>1</sup>, Ji-Bin Liu<sup>1</sup>, John Eisenbrey<sup>1</sup>, Flemming Forsberg<sup>1</sup>**

<sup>1</sup>Radiology, Thomas Jefferson University, Philadelphia, PA USA; <sup>2</sup>School of Biomedical Engineering, Sciences, and Health Systems, Drexel University, Philadelphia, PA USA; <sup>3</sup>Plymouth Whitemarsh High School, Plymouth Meeting, PA USA; <sup>4</sup>Trinity College, Hartford, CT USA

**Objectives:** To noninvasively estimate in vivo tumor interstitial fluid pressure (IFP) in female nude athymic rats implanted with breast cancer xenografts using subharmonic aided pressure estimation (SHAPE) and compare results to an invasive intracompartmental pressure monitor (the reference standard). Also to monitor changes due to chemotherapy treatment.

**Methods:** Eighty-nine female nude athymic rats were injected in the mammary fat pad with  $5 \times 10^6$  breast cancer cells (MDA-MB-231). Animals were randomly assigned to a calibration group ( $n = 25$ ) or a treatment group ( $n = 64$ ), with the treatment group receiving a single injection of 5 mg/kg paclitaxel (Mayne Pharma, Paramus, NJ). Radiofrequency signals were acquired with a Sonix RP ultrasound scanner (Analogic Ultrasound, Richmond, BC, Canada) using a linear array (L9-4; trans-

mit/receive: 8/4 MHz). The contrast agent Definity (Lantheus Medical Imaging, North Billerica, MA) was injected into a tail vein (dose: 180  $\mu$ L/kg), and acoustic power was varied from 0 to –20 dB to identify the optimal choice for SHAPE. Measurements from the tumors and surrounding tissue were obtained (in triplicate) after contrast administration at the optimal acoustic power. SHAPE IFP estimates were compared to an invasive pressure monitor (Stryker, Berkshire, UK) using linear regression analysis.

**Results:** Fifty rats developed tumors (56%), and 39 were successfully imaged (13 and 26 for calibration and treatment, respectively). Tumor flow was clearly visualized in the tumor periphery, while slow capillary-type flow was more difficult to depict. An inverse linear relationship was established between tumor IFP and SHAPE ( $y = -1.06x + 28.27$ ;  $r = -0.69$ ;  $P = .01$ ) based on the calibration group. Using this relationship in the treatment group resulted in an  $r$  value of 0.74 ( $P < .05$ ) between measured and estimated IFP values with an average error of 6.24 mm Hg. No significant differences in tumor IFP were seen before and after paclitaxel treatment with either SHAPE or the Stryker technique ( $P \geq .15$ ).

**Conclusions:** A calibration equation for in vivo studies of breast tumor IFP using SHAPE has been derived and verified in an independent population. SHAPE IFP estimates may be useful in future clinical breast studies.

#### 2385253 Four-Dimensional Subharmonic Contrast Imaging for Monitoring Neoadjuvant Chemotherapy of Breast Cancer Flemming Forsberg<sup>1</sup>, \* Maria Stanczak<sup>1</sup>, Elizabeth Hsu<sup>1</sup>, Anush Sridharan<sup>1,4</sup>, Adam Berger<sup>3</sup>, Tiffany Avery<sup>2</sup>, John Eisenbrey<sup>1</sup>

<sup>1</sup>Radiology, <sup>2</sup>Medical Oncology, <sup>3</sup>Surgery, Thomas Jefferson University, Philadelphia, PA USA; <sup>4</sup>Electrical and Computer Engineering, Drexel University, Philadelphia, PA USA

**Objectives:** To determine if breast tumor vascularity or interstitial fluid pressure (IFP) measured by 4D subharmonic imaging (SHI) can be used as a predictor of neoadjuvant chemotherapy response.

**Methods:** Seventeen patients scheduled for neoadjuvant treatment (approximately 16 therapy cycles over 3–6 months) of a primary breast cancer provided informed consent to undergo ultrasound exams immediately prior to starting therapy, at 10% and 60% through the course of therapy, as well as at the conclusion of therapy. Scanning was performed using a modified LOGIQ 9 scanner with a 4D10L probe (GE Healthcare, Milwaukee, WI). Experimental software enabled 4D pulse inversion SHI (transmitting 4 cycle pulses at 5.8 MHz and receiving at 2.9 MHz) and collection of radiofrequency data for the estimation of IFP using subharmonic-aided pressure estimation (SHAPE). Subjects first underwent 3D B-mode and Doppler imaging of the mass. Patients then received a continuous infusion of Definity (Lantheus Medical Imaging, North Billerica, MA) at acoustic pressures optimized for either SHI or SHAPE. The relative changes in blood flow and IFP were scored (from –3 to 3, where 0 indicates baseline conditions). Results were grouped by complete (>99% reduction in tumor volume) or partial treatment response and compared with Mann-Whitney tests.

**Results:** To date, 8 subjects have completed all 4 exams, while 1 subject has received 3 of 4 scans and another 3 have completed 2 of 4 exams. Overall, 42 SHI studies have been performed. Volume acquisition rates ranged from 0.6–3.2 volumes/second. Five patients saw complete resolution of the primary mass, while 3 subjects achieved a partial response only. Complete responders demonstrated greater vascularity at baseline and a greater overall change in flow and IFP relative to partial responders, albeit not statistically significant ( $P > .19$ ). Additionally, fully responding masses showed a trend toward significance for decreased tumor vascularity at 60% and completion compared to partial responders ( $P = .07$ –.08).

**Conclusions:** Preliminary results indicate that changes in breast cancer vascularity and in IFP observed on 4D SHI and SHAPE may predict neoadjuvant chemotherapy treatment response.

### Contrast-Enhanced Ultrasound

Moderator: Andrej Lyshchik, MD, PhD

#### 2363290 Contrast-Enhanced Transrectal Ultrasound of the Prostate With Whole-Mount Prostatectomy Correlation: Analysis of Racial Differences

Ethan Halpern<sup>1</sup>, \* Edouard Trabulsi<sup>2</sup>

<sup>1</sup>Radiology, <sup>2</sup>Urology, Thomas Jefferson University, Philadelphia, PA USA

**Objectives:** Racial differences exist in the clinical presentation and course of prostate cancer (PCa). This study investigates racial differences in contrast-enhanced transrectal ultrasound (CE-TRUS) for detection of clinically significant PCa among patients with whole-mount radical prostatectomy correlation.

**Methods:** We retrospectively identified 58 subjects with CE-TRUS studies who subsequently underwent radical prostatectomy with whole-mount pathology. Each patient underwent evaluation with CE-TRUS during intravenous infusion of perflutren lipid microspheres (Definity; Lantheus Medical Imaging, North Billerica, MA). A maximum of 5 targeted biopsy cores were obtained from each subject based on CE-TRUS findings, followed by a 12-core systematic (medial and lateral sextant) biopsy. Pathology maps of the prostate were digitized, and tumor volumes were measured.

**Results:** Our 58 subjects included 51 Caucasian, 5 African American, and 2 Hispanic men. Mean gland size of 39.6 cm<sup>3</sup>, percent gland involvement of 9.1%, and absolute PCa volume of 3.6 cm<sup>3</sup> were similar for all races ( $F$  test,  $P > .3$ ). High-grade PCa, defined as Gleason score  $\geq 7$ , was present in 13/58 (22.4%) of whole-mount specimens, with no significant racial differences ( $P = .7$ ). PCa was detected by our limited targeted biopsy approach using CE-TRUS guidance in 45/58 patients and by systematic 12 core biopsy alone in 13/58 patients (including both Hispanic patients who were identified only by systematic biopsy). The per-patient detection rate of targeted biopsy based on CE-TRUS was equally good ( $\approx 80\%$ ) among both Caucasian and African American patients. Among 52 patients with clinically significant PCa defined by tumor volume  $> 0.5$  cm<sup>3</sup> or Gleason score  $\geq 7$ , abnormalities on CE-TRUS were prospectively detected in 49/52 (sensitivity = 94%).

**Conclusions:** CE-TRUS demonstrates increased enhancement in 94% of “clinically significant” PCa. Targeted biopsy based on CE-TRUS detects approximately 80% of PCa with a limited biopsy approach using up to 5 biopsy cores. There was no significant difference in the PCa detection rate between Caucasian and African American patients.

#### 2381002 Size Measurements of Hepatocellular Carcinoma: Comparisons Between Contrast and 2-Dimensional Ultrasound

Fei Wang<sup>1</sup>, \* Zheng Liu<sup>2</sup>, Mei Zhu<sup>1</sup>, Fei Chen<sup>2</sup>, Wenhong Gao<sup>2</sup>

<sup>1</sup>Ultrasound, First Affiliated Hospital of Kunming Medical University, Kunming, China; <sup>2</sup>Ultrasound, Xinqiao Hospital, Third Military Medical University, Chongqing, China

**Objectives:** Size measurement is essential in tumor imaging. Ultrasound (US) imaging is known to clinically underestimate tumor size. This study is aimed to compare the size measurements of hepatocellular carcinoma (HCC) in 3 US imaging modalities: ie, 2-dimensional (2D) imaging and arterial phase and delayed phase imaging with contrast-enhanced US (CEUS).

**Methods:** Fifty-eight patients with clinically proved HCC were included. The maximal tumor diameter ranged from 1.85–11.2 cm. The 2D and CEUS imaging were performed with Siemens S2000, Philips iU22, and Biosound Esaote MyLab TWICE US imaging systems; 2.5 mL of SonoVue was injected for every CEUS performance. One physician measured the maximal longitudinal and transverse diameters of the tumors in



2D, the arterial phase, and the delayed phase of CEUS from 1 image section. The 3 measurements were compared by paired *t* test.

**Results:** The mean longitudinal diameter of HCC appeared to be maximal in the arterial phase ( $4.73 \pm 2.04$  cm) of CEUS and minimal in the delayed phase ( $3.98 \pm 1.99$  cm) of CEUS. The 2D diameter ( $4.26 \pm 2.07$  cm) was in the middle between the 2 CEUS measurements. There were significant differences between any 2 measurements.

**Conclusions:** There are size differences between the 3 kinds of HCC measurement. The tumor size appeared to be maximal in the arterial phase of CEUS and minimal in the delayed phase, whereas the 2D diameter was in the middle.

#### 2381690 Characterization of Pancreatic Masses With Subharmonic and Endoscopic Contrast Ultrasound

*Flemming Forsberg<sup>1</sup>, \* Maria Stanczak<sup>1</sup>, Andrej Lyshchik<sup>1</sup>, David Loren<sup>2</sup>, Patrick O'Kane<sup>1</sup>, Ali Siddiqui<sup>2</sup>, Thomas Kowalski<sup>2</sup>, Cynthia Miller<sup>2</sup>, Traci Fox<sup>1,3</sup>, Ji-Bin Liu<sup>1</sup>, John Eisenbrey<sup>1</sup>*

<sup>1</sup>Radiology, <sup>2</sup>Gastroenterology and Hepatology, <sup>3</sup>Radiologic Sciences, Thomas Jefferson University, Philadelphia, PA USA

**Objectives:** To demonstrate the feasibility of using subharmonic imaging (SHI) to depict and characterize pancreatic masses in humans and to compare results to contrast-enhanced endoscopic ultrasound (EUS) as well as to pathology.

**Methods:** Sixteen patients scheduled for an EUS-guided biopsy of a pancreatic mass were enrolled in an Institutional Review Board–approved study. Pulse inversion SHI (transmitting/receiving at 2.5/1.25 MHz) was implemented on a LOGIQ 9 ultrasound scanner (GE Healthcare, Milwaukee, WI) with a 4C probe. Contrast harmonic EUS (transmitting at 4.7 MHz and receiving at 9.4 MHz) was performed with a radial endoscope (GF-UTC180; Olympus, Tokyo, Japan) connected to a ProSound SSD  $\alpha$ 10 scanner (Hitachi-Aloka, Tokyo, Japan). Two injections of the contrast agent Definity (Lantheus Medical Imaging, North Billerica, MA) were administered (dosages of 0.3–0.4 and 0.6–0.8 mL for EUS and SHI, respectively). Contrast-to-tissue ratios (CTRs) in the mass and an adjacent vessel were calculated offline for both modes and compared using paired *t* tests. Four blinded physicians independently scored the contrast images on a 5-point scale (benign to malignant). Receiver operating characteristic (ROC) curves (4 in all) for diagnostic accuracy and  $\kappa$  values for inter-reader agreement were calculated.

**Results:** One subject dropped out before imaging, leaving 11 adenocarcinoma, 1 gastrointestinal stromal tumor with pancreatic infiltration, and 3 benign cases. Marked subharmonic signals and reasonable tissue suppression were obtained in all subjects with intratumoral blood flow clearly visualized using transabdominal SHI. Significantly greater CTRs were obtained in the masses with SHI than with EUS ( $1.71 \pm 1.63$  vs  $0.63 \pm 0.89$ ;  $P = .016$ ). In the larger surrounding vessels, SHI and contrast EUS CTRs were similar ( $P = .72$ ). There were no differences in CTR when grouped by pathology ( $P > .60$ ). The areas under the ROC curves were 0.09 and 0.52 for contrast EUS, while for SHI they were 0.45 and 0.32 with greater  $\kappa$  values for the latter (0.34 vs 0.13 for EUS).

**Conclusions:** The diagnostic accuracy of contrast EUS and transabdominal SHI for assessment of pancreatic masses was quite low in this pilot study. However, SHI demonstrated better agreement between readers and improved tumoral CTRs relative to contrast EUS.

#### 2382015 Preliminary Clinical Application of Contrast-Enhanced Ultrasound Using a High-Frequency Linear Probe in the Detection of Small Colorectal Liver Metastases

*Qin Si, Guangjian Liu\**

*Medical Ultrasonics, Sixth Affiliated Hospital of Sun Yat-Sen University, Guangzhou, China*

**Objectives:** To compare the performance of contrast-enhanced ultrasound (CEUS) using a high-frequency linear probe and routine convex probe in the detection of small colorectal liver metastases (CRLMs).

**Methods:** Sixty-six CRLMs in 38 patients were evaluated with both ultrasound (US) and CEUS by using a convex probe and linear probe respectively. The size of lesions  $\pm$  SD was  $7.3 \pm 2.1$  mm (range, 3.0–10.0 mm, measured by CECT/magnetic resonance imaging). US and CEUS were performed with a LOGIQ E9 (GE Healthcare, Milwaukee, WI) equipped with a convex probe (C1-5, frequency range from 3.0–5.0 MHz) and a linear probe (9L, frequency range from 6.0–9.0 MHz). The contrast agents used in CEUS were SonoVue (Bracco, Milan, Italy). Imaging findings and detection rates of both US and CEUS were reviewed and compared.

**Results:** On baseline US, for the 53 lesions within 60 mm, high-frequency US detected more than routine US (79% vs 58%;  $P < .05$ ). The boundary and halo sign were depicted more clearly by using the high-frequency linear probe compared with the convex probe ( $P < .05$ ). On CEUS, 48 lesions (73%) were detected by using the convex probe, and 54 lesions (82%) were detected by using the linear probe, with no statistical difference ( $P > .05$ ). However, for the lesions within 60 mm, high-frequency CEUS detected more than routine CEUS (89% vs 66%;  $P < .05$ ). Combining the convex probe and linear probe, CEUS detected 97% (64/66) of all the lesions, which was significantly higher than baseline US (97% vs 85%;  $P < .05$ ). For enhancement levels and patterns, there was a statistical difference between routine CEUS and high-frequency CEUS in the arterial phase ( $P < .05$ ).

**Conclusions:** High-frequency CEUS may help improve not only the detection of tiny CRLMs but also depiction of the tumor vascularization. For patients with a high risk of CRLMs, we recommend the combination of a convex probe and high-frequency linear probe for CEUS to detect and characterize CRLMs in clinical practice.

#### 2383496 Double Contrast-Enhanced Ultrasound for Diagnosis of Gastric Subepithelial Tumors

*Man Lu*

*Ultrasound, Sichuan Academy of Medical Sciences and Sichuan Provincial People's Hospital, Chengdu, Sichuan, China*

**Objectives:** To explore the application value of double contrast-enhanced ultrasound (DCEUS) in the diagnosis of gastric subepithelial tumors.

**Methods:** A total of 172 cases of gastric subepithelial lesions were covered (from January 2013 to May 2015), and the various patterns of DCEUS in different subepithelial lesions were summarized to compare with pathology results in every patient.

**Results:** Of the 172 lesions, 37 were gastric cancers (Borrmann I; 21.5%), 47 were gastrointestinal stromal tumors (27.3%), 12 were lymphomas (7.0%), 7 were inflammatory masses (4.1%), 35 were polypoid adenomas (20.3%), 11 were gastric cysts (6.4%), 7 were ectopic pancreas (4.1%), 5 were lipomas (2.9%), 4 were glomus tumors (2.3%), 5 were leiomyomas (2.9%), and 2 were schwannomas (1.2%). Perfusion patterns vary in different lesions, and they are connected to histopathology and malignant degree.

**Conclusions:** The presentation of different DCEUS perfusion pattern in 172 gastric subepithelial lesions could be treated as a novel and reliable diagnostic tool to identify the different kinds of subepithelial tumors, and DCEUS surveillance can be an appropriate strategy for lesions.



### 2384518 Dynamic Contrast-Enhanced Ultrasound and Elastography for Assessing Deltoid Muscle Integrity After Reverse Shoulder Arthroplasty

Christian Fischer<sup>1</sup>,\* Daniel Krammer<sup>1</sup>, Thomas Bruckner<sup>3</sup>, Martin Krix<sup>2</sup>, Marc-André Weber<sup>2</sup>, Gerhard Schmidmaier<sup>1</sup>, Andreas Hug<sup>1</sup>, Felix Zeifang<sup>1</sup>

<sup>1</sup>Center for Orthopedics, Trauma Surgery, and Spinal Cord Injury, <sup>2</sup>Diagnostic and Interventional Radiology, Heidelberg University Hospital, Heidelberg, Germany; <sup>3</sup>Institute of Medical Biometry and Informatics, University of Heidelberg, Heidelberg, Germany

**Objectives:** Reverse shoulder arthroplasty (RSA) is the treatment of choice for cuff tear arthropathies. The condition of the deltoid muscle plays a key role in the outcome of RSA, which we assessed with contrast-enhanced ultrasound (DCE-US), elastography, and electromyography.

**Methods:** Sixty-four patients (mean age, 72.9 years) who were treated with RSA between 2004 and 2013 were recruited. Clinical, functional, electromyography, and ultrasound examinations were performed to assess the long-term outcome. DCE-US perfusion parameters such as wash-in rate (WiR) and wash-in perfusion index (WiPI) were recorded and referenced to the posterior humeral circumflex artery. The results of the healthy and operated shoulders were compared in order to rate the vitality of the deltoid muscle based on the microperfusion of the muscle tissue.

**Results:** There were significant functional differences between both shoulders (eg, Constant score =  $-14 \pm 24$ ;  $P < .0001$ ) as well as in DCE-US (WiR =  $-15.7\% \pm 29.9\%$ ;  $P = .0002$ ; WiPI =  $-12.0\% \pm 22.0\%$ ;  $P = .0001$ ). Elastography showed a higher stiffness of the deltoid muscle on the operated side (difference =  $0.2 \pm 0.9$  m/s;  $P = .0545$ ). The postoperative interval did not have any impact on these differences. Electromyography did not show any signs of neurologic injury in the study patients.

**Conclusions:** The DCE-US analysis showed diminished microperfusion kinetics of the operated deltoid muscle with slower blood flow and lower blood volume. These results correlated with the functional impairment after RSA and can be interpreted as signs of degenerative changes in the muscle. DCE-US serves as a surrogate parameter for the integrity of the deltoid muscle.

### 2384901 Contrast-Enhanced Ultrasound in Small Indeterminate Renal Lesions

Jessica Zarzour<sup>1</sup>,\* Janelle West<sup>2</sup>, Eric Turner<sup>2</sup>, Bradford Jackson<sup>2</sup>, Mark Lockhart<sup>1</sup>, Michelle Robbin<sup>1</sup>

<sup>1</sup>Radiology, University of Alabama, Birmingham, AL USA; <sup>2</sup>University of Alabama, Birmingham, AL USA

**Objectives:** To determine the value of contrast-enhanced ultrasound (CEUS) in small renal lesions indeterminate on prior imaging.

**Methods:** This Institutional Review Board–approved, retrospective study evaluated all patients who underwent CEUS from 2006–2015 at our tertiary care hospital. Renal lesions initially deemed indeterminate by computed tomography (CT), ultrasound (US), or magnetic resonance imaging (MRI) were evaluated by CEUS. Cystic lesions were categorized by the Bosniak classification system, and solid enhancing masses were labeled as solid. We compared the number of lesions definitively characterized by CEUS with the indeterminate lesions by prior imaging. The accuracy of CEUS was analyzed and compared with the final diagnosis by histology.

**Results:** Of 134 renal lesions evaluated by CEUS, 108 were indeterminate by prior imaging. Mean  $\pm$  SD lesion size was  $2.9 \pm 1.8$  cm. Sixty-nine renal lesions were indeterminate on prior CT due to equivocal enhancement of 10–20 Hounsfield units ( $n = 21$ ), noncontrast scan only ( $n = 39$ ), or venous phase only ( $n = 8$ ). Six lesions were indeterminate by MRI due to lack of contrast, and 36 lesions were indeterminate by conventional US. Of 108 renal lesions indeterminate by prior imaging, 79.6%

were definitively diagnosed by CEUS (95% confidence limits (CL), 0.71, 0.88;  $P < .0001$ ). Specifically, CEUS was definitive for 83.6% of lesions deemed indeterminate by CT (95% CL, 0.73, 0.92;  $P < .0001$ ); 100% of lesions were indeterminate by MRI (95% CL, 0.54, 1.0;  $P = .0143$ ); and 73.7% of lesions were indeterminate by prior US (95% CL, 0.57, 0.87;  $P = .0035$ ). Of those that were indeterminate on prior CT, 41.1% were classified as Bosniak 1 or 2, 16.1% as Bosniak 2f, 21.4% as Bosniak 3 or 4, and 21% as solid enhancing masses. CEUS was definitive for characterization of renal lesions in 85.0% of patients with end-stage renal disease (95% CL, 0.62, 0.97;  $P = .0017$ ) and in 85.4% of patients with a glomerular filtration rate  $< 60$  (95% CL, 0.76, 0.92;  $P < .0001$ ). Of the 24 lesions classified as Bosniak 3, Bosniak 4, or solid enhancing mass, 22 went on to pathologic diagnosis. Sensitivity was 100% ( $P < .0001$ ), positive predictive value was 0.91 ( $P < .0001$ ), and accuracy was 90.1%.

**Conclusions:** CEUS is frequently useful for definitive characterization of small renal masses that were indeterminate by prior imaging, especially in patients with previous indeterminate MRI or CT.

### 2385019 Preoperative Tumor Studies Using Contrast-Enhanced Ultrasonography in Patients With Clinically Suspected Insulinoma

Miaomiao Zhang

Xijing Hospital, Fourth Military Medical University, Xi'an, China

**Objectives:** Insulinomas are relatively rare pancreatic endocrine tumors. These insulinomas with a diameter less than 1 cm are very difficult to be identified. The aim of this study was to localize and diagnose insulinomas preoperatively using contrast-enhanced ultrasonography (CEUS) in correlation with postoperative pathologic results.

**Methods:** A total of 38 consecutive patients with clinically suspected insulinoma were surgically treated in our hospital between November 2004 and March 2015. CEUS was performed before the operation. The echogenicity, shape, diameter, localization, and number of tumors were described. SonoVue was applied intravenously through the cubital vein as a 2.4-mL bolus injection within 5 seconds, followed by a 10-mL saline flush. Then we observed the dynamic enhancement of pancreas to confirm whether there were abnormal nodules and to analyze the enhancement patterns. The characteristics of lesions from the preoperative and intraoperative ultrasonography reports and operation reports were analyzed retrospectively and compared with postoperative pathologic findings.

**Results:** A total of 34 cases were located accurately. In the arterial phase, 37 lesions were enhanced. Moreover, the lesions were still enhanced in the venous phase. The enhancement pattern of insulinoma on CEUS was fast wash-in and slow wash-out. In the arterial phase, 1 lesion enhanced inhomogeneously with a filling defect in the center, and it faded away earlier than the rest of the pancreas during the venous phase. Tumor sizes ranged from  $6 \times 6$  to  $31 \times 37$  mm. Enucleation was carried out in 20 patients, Whipple in 6, segmental resection in 5, distal pancreatectomy in 5, and intraoperative radiofrequency in 2. The operations were successful, and the mortality rate was 0%. Pathologic findings were insulinoma in 37 cases. One patient had neuroendocrine tumors.

**Conclusions:** We conclude that the preoperative localization of insulinoma in clinically suspected patients can be made by CEUS. There are characteristics for insulinoma on CEUS. Preoperative localization of insulinoma is very important for choosing the appropriate surgical procedure.

### 2385711 Value of Contrast-Enhanced Ultrasonography in Confident Diagnosis of Ovarian Torsion: Initial Experience

Shenaz Momin<sup>1</sup>, \*Asif Momin<sup>2</sup>

<sup>1</sup>Radiology, B. Y. L. Nair Hospital, Mumbai, India; <sup>2</sup>Imaging, Prince Aly Khan Hospital, Mumbai, India

**Objectives:** B-mode ultrasonography (US) along with color duplex imaging is known to help in diagnosis of suspected ovarian torsion. In the appropriate clinical setting, identification of a twisted pedicle (snail sign and whirlpool sign) with or without absence of intraovarian color flow is a highly useful sign, with unilateral ovarian enlargement and trapped follicles being the commonest features. In young patients it is always difficult to prepare a patient or parents for emergency surgery such as oophorectomy. Adding contrast-enhanced ultrasonography (CEUS) as an adjunct just prior to sending the patient for surgery has shown additional diagnostic value in our series.

**Methods:** We could use CEUS in 4 cases in the last 7 months in our small community hospital. The patient age group was 4–33 years, all presenting with acute lower abdominal pain but without any preexisting ovarian lesion such as a cyst or solid tumor. On initial B-mode US using various signs, clinical history, and acute onset of presentation, a tentative diagnosis of ovarian torsion was established. This was communicated to the surgeon, and with prior consent CEUS using 2 mL of intravenous sulfur hexafluoride microbubbles (SonoVue; Bracco; which is approved in our country for human use), review US was done on high-end ultrasound units with suitable abdominal probes.

**Results:** CEUS did not reveal any microbubble uptake on the suspected side compared to the normal ovary; hence, a confident diagnosis was given. Emergency laparoscopic ovarian detorsion was achieved in time, with establishment of vascular supply. Orchidopexy was done in 3 cases, including a 4-year-old girl. In 1 case, revascularization was sub-optimal; hence, oophorectomy was done due to severe gangrenous change.

**Conclusions:** In a suspected case of ovarian torsion, quick add-on CEUS helps in establishing the diagnosis. This is important for avoiding interim delay, especially in younger patients prior to emergency surgery. CEUS is safer and faster than further contrast-enhanced computed tomography with added radiation exposure, as seen in our institute, where US is still the initial and at times the only available diagnostic tool in emergency conditions such as gonadal torsion.

### 2385754 Value of Ultrasound Contrast Agents in the Diagnosis of Endoleaks in Patients With Abdominal Aortic Aneurysms Treated With Stent Graft Implantations

Anna Drelich-Zbroja, \*Tomasz Jargiello, Michal Sojka, Malgorzata Szerbo-Trojanowska

Interventional Radiology and Neuroradiology, Medical University Lublin, Lublin, Poland

**Objectives:** To assess the value of ultrasound contrast agents in the diagnosis of endoleaks in patients with abdominal aortic aneurysms (AAAs) treated by stent graft implantation.

**Methods:** A total of 198 patients with AAAs were referred to our department for stent graft implantation. In every patient, control examinations were done 6 months after treatment. First ultrasound examinations before and after contrast administrations were done, and next angio-computed tomography (CT) was performed. In every ultrasound examination, color, power, and B-flow options were used before and after contrast injections, and additionally, contrast-enhanced ultrasound (CEUS) was performed after contrast administration.

**Results:** In control ultrasound examinations performed 6 months after stent graft implantations before contrast injections, in all options (color, power, and B-flow), 16 endoleaks were diagnosed: 6 type IA, 4 type IB, 2 type IIA, and 4 type IIB. In control ultrasound examinations after contrast injections using color, power, and B-flow options, 16 known endoleaks were confirmed, and additionally, 6 endoleaks were diagnosed:

1 type IB, 2 type IIA, and 3 type IIB. In CEUS examinations after contrast administration, 22 diagnosed endoleaks were confirmed, and additionally, 4 endoleaks were diagnosed: 2 type IIA and 2 type IIB. In angio-CT examinations, 22 endoleaks were diagnosed: 6 type IA, 5 type IB, 4 type IIA, and 7 type IIB.

**Conclusions:** Ultrasound contrast agents significantly increased the sensitivity of ultrasound examinations in the diagnosis of endoleaks, particularly type II. CEUS studies show the greatest sensitivity in detecting the endoleaks because they disclose endoleaks unrecognized by other techniques, including angio-CT. Ultrasound examinations after contrast injection can replace angio-CT in monitoring patients after stent graft implantations.

### General, Abdominal, and Interventional-Intraoperative Ultrasound

Moderator: Nirvikar Dahiya, MD

### 2351545 Ultrasound of Human Papillomavirus Cancers in the Base of the Tongue and Tonsils

M. Robert De Jong<sup>1</sup>, \*Carole Fakhry<sup>2</sup>, Stephanie Coquia<sup>1</sup>, Marianna Holman<sup>1</sup>, Ulrike Hamper<sup>1</sup>

<sup>1</sup>Radiology, Ultrasound, <sup>2</sup>Head and Neck Surgery, Johns Hopkins Hospital, Baltimore, MD USA

**Objectives:** To demonstrate how ultrasound can show masses in the base of the tongue and tonsils using normal scanning techniques through the neck. To discuss the pitfalls of magnetic resonance imaging (MRI) and computed tomography (CT) and learn how ultrasound is a viable alternative to imaging these patients.

**Methods:** Using Siemens S3000 and Philips Epiq units with a variety of transducer types and frequencies, we were able to visualize the normal and abnormal tonsils and base of tongue, as well as any associated lymph nodes. We scanned patients with known human papillomavirus cancer of the oropharynx. Patients also had to have a recent CT or MRI scan for comparison and validation of pathology.

**Results:** In our initial group of 15 patients, we visualized both normal and abnormal tonsils, including 1 patient with an enlarged tonsil that was suspicious for a cancer on physical examination. We demonstrated extension of the tumor from the tonsil into the tongue in 2 patients. We were able to visualize the extent of tumors in patients who had dental artifacts on CT and MRI.

**Conclusions:** Using standard scanning techniques and equipment, ultrasound can be used to visualize cancers of the tonsils and base of the tongue, overcoming some of the obstacles of CT and MRI, such as contrast, radiation, and dental artifacts, thus helping surgeons in their planning of treatment for patients.

### 2376078 Sonographic Appearance of Topical Hemostatic Agents With Computed Tomographic and Magnetic Resonance Imaging Correlation and Long-term Follow-up

Brett Walker, \*Howard Heller, Cheryl Sadow, Mary Frates  
Radiology, Brigham and Women's Hospital/Harvard Medical School, Boston, MA USA

**Objectives:** To describe the sonographic appearances of topical hemostatic agents, correlate with other imaging, and distinguish imaging features from pathology.

**Methods:** Patients were identified by key word search of an ultrasound (US) report database. Operative notes were reviewed, and patients were excluded if placement of a hemostatic agent was not documented. US, computed tomography (CT), and magnetic resonance imaging (MRI) studies were also reviewed.

**Results:** Twelve patients were treated with the following agents: Floseal (3), Gelfoam (3), Surgicel (2), and a combination of agents

(4). Imaging performed included US only (5), US and CT (5), and US, CT, and MRI (2). Procedures included ovarian cystectomy (3), cesarean section (5), exploratory laparotomy (1), cholecystectomy (1), partial nephrectomy (1), and cervical cone biopsy (1). Imaging characteristics were as follows. Floseal appeared echogenic early, became hypoechoic, and then resolved. Gelfoam was initially hypoechoic or not visible and then echogenic. Long-term follow-up of Gelfoam showed dense echogenic shadowing at US, calcification at CT, and a hypointense T2 signal at MRI. Surgicel had an echogenic shadowing appearance early; no long-term studies were available. Combinations of agents resulted in a variety of appearances. Four patients had subsequent intervention in the area of the agent due to abnormal CT imaging: 3 to exclude abscesses and 1 to exclude a recurrent tumor. Only 2 of these were positive for pathology.

**Conclusions:** Topical hemostatic agents have a characteristic US and cross-sectional imaging appearance that changes over time. Recognition of the appearance of commonly used agents is crucial to avoid misdiagnosis.

#### 2378969 Detection of Transplant Renal Artery Stenosis: Determining Normal Velocities at the Renal Artery Anastomosis

Kristin Robinson<sup>1</sup>, \*J. Scott Kriegshauser<sup>1,2</sup>, Nirvikar Dahiya<sup>1</sup>, Scott Young<sup>1</sup>, Christopher Czaplicki<sup>1</sup>, Maitray Patel<sup>1</sup>

<sup>1</sup>Diagnostic Radiology, <sup>2</sup>Interventional Radiology, Mayo Clinic Hospital, Phoenix, AZ USA

**Objectives:** Spectral Doppler evaluation of peak systolic velocity (PSV) at the renal artery anastomosis (RAA) exceeding 250 cm/s has been historically used to suspect significant transplant renal artery stenosis (TRAS). However, the mean and range of RAA PSV in transplants without TRAS have not been well established. Defining this range is the aim of this investigation.

**Methods:** A retrospective analysis of renal transplantations at a single institution over 5 years was performed to identify patients without graft dysfunction, failure, or refractory hypertension. The RAA PSVs obtained in the immediate postoperative period and on interval sonograms closest to 1, 4, and 12 months after transplant were recorded.

**Results:** Of 1141 patients, 127 with graft dysfunction/failure/death, 157 with more than 1 renal artery anastomosis, and 13 with clinically suspected or confirmed TRAS were excluded; 844 patients met inclusion criteria (age range 18–83 years; 489 males). Mean RAA PSV for 377 patients evaluated within 2 days of transplant (mean, 1 day) measured  $195 \pm 103$  cm/s; 97 patients (26%) had RAA PSV  $>250$  cm/s, with 18 patients (5%) having RAA PSV  $>401$  cm/s (mean + 2 SD). Mean RAA PSV for 820 patients evaluated between 3 and 60 days after transplant (mean, 34 days) measured  $206 \pm 91$  cm/s; 224 patients (27%) had RAA PSV  $>250$  cm/s, with 29 (4%) exhibiting PSV  $>388$  cm/s (mean + 2 SD). Mean RAA PSV for 785 patients evaluated between 60 and 273 days after transplant (mean, 131 days) measured  $203 \pm 86$  cm/s; 201 patients (26%) had RAA PSV  $>250$  cm/s, with 32 patients (4%) exhibiting RAA PSV  $>375$  cm/s (mean + 2 SD). Mean RAA PSV for 766 patients evaluated 330–766 days after transplant (mean, 394 days) measured  $189 \pm 76$  cm/s; 141 patients (18%) had RAA PSV  $>250$  cm/s, with 26 (3%) exhibiting RAA PSV  $>341$  cm/s (mean + 2SD).

**Conclusions:** Approximately 26% of patients without TRAS will have RAA PSV exceeding 250 cm/s in the first 9 months, dropping to 18% at 1 year. Using a 250-cm/s threshold for suspicion of TRAS would result in many false-positive assessments. A more appropriate threshold may be 2 SD above the mean, which translates to 340–400 cm/s.

#### 2380816 Gallstone Prevalence in the Ngobe Population

Leigh Goodrich\*, Michael Butler, Logan Woodhouse, Jillian Gottlieb, Roxanne Talamayan-Pascua, Nicole Salame, Ivy Ewald, Marie-Claire Matsuo, Anna-Marie Hosking, Alyssa Velasco

University of California, Irvine, CA USA

**Objectives:** The objective of this study is to quantify the prevalence of gallstones in the Ngobe population of rural Panama and investigate potentially significant risk factors. By focusing on the indigenous Ngobe communities off the northwest coast of Panama, the aim is to characterize the prevalence of gallstones in a specific demographic using modern ultrasound technology. Similar studies focusing on particular population groups have found prevalence rates of gallstones between 5.9% in Ghana (Gyedu et al, 2015) and 15% in Sweden (Muhrbreck et al, 1995). Assessing the dietary and lifestyle factors unique to the Ngobe communities can elucidate potentially significant risk factors.

**Methods:** The ultrasound and survey data used for this study were obtained by 10 University of California Irvine medical students over 8 weeks in rural Panama through a partnership with Floating Doctors, a nonprofit organization that provides health care to indigenous Ngobe communities. The primary outcome of interest is the prevalence of gallstones within the Ngobe population. The secondary concern is potential risk factors associated with gallstone development. Each patient answered a set of questions determining their age, weight, height, body mass index (BMI), sex, diet, family history, pregnancy status, ongoing symptoms (nausea/vomiting), and physical exam findings (including Murphy's sign).

**Results:** There were a total of 80 participants; 70% were females. Mean age was  $39 \pm 14$  years. Of the 74 participants who had BMI data, the mean BMI was  $30.8 \pm 5.5$ . Prevalence of cholelithiasis was 11.25%. Females had a higher prevalence compared to males (14.28 vs 4.16). Further analysis of risk factor data is pending.

**Conclusions:** The prevalence of gallstones in the Ngobe population screened at Floating Doctors clinics was 11.25%, a higher rate than has been reported in previous studies. There was a higher prevalence in females compared to males. Other conclusions regarding the particular risk factors important in this population's development of gallstones are pending full analysis of the data. We expect to comment on each of the criteria recorded in the surveys and discuss whether each general gallstone risk factor was indeed a statistically significant risk factor for these patients.

#### 2381102 What's All the Noise About? Detecting Post-Transplant Hepatic Vein Stenosis With Doppler Ultrasound Versus Venography

Sara Plett<sup>1,2</sup>, \*David Valenzuela<sup>2</sup>, Nicholas Fidelman<sup>1</sup>, Andrew Taylor<sup>1</sup>, Kanti Kolli<sup>1</sup>, Evan Lehrman<sup>1</sup>, Jeanne Laberge<sup>1</sup>, Robert Kerlan<sup>1</sup>, Vickie Feldstein<sup>2</sup>, Maureen Kohli<sup>1</sup>

<sup>1</sup>Interventional Radiology, <sup>2</sup>Radiology and Biomedical Imaging, Ultrasound Imaging, University of California, San Francisco, CA USA

**Objectives:** Hepatic venography with pressure measurements is often considered the “gold standard” for the diagnosis of hepatic vein stenosis in the post-liver transplant patient. We compare transjugular hepatic venography with Doppler ultrasound to detect hepatic venous outflow stenosis after liver transplantation.

**Methods:** A retrospective review of 87 consecutive patients (mean age,  $52 \pm 15$  years; 60% male) with liver transplantation who underwent transjugular liver biopsy between July 2011 and August 2014 was performed. Pressure measurements in the right atrium and hepatic veins were performed. Venography images were reviewed to identify hepatic venous outflow stenosis. Concurrent Doppler ultrasound images of the hepatic veins were also reviewed, with waveform tracings graded as “normal” (triphasic or biphasic) versus “abnormal” (monophasic). Pathology reports were evaluated for sinusoidal congestion suggestive of venous out-



flow obstruction, and transthoracic echocardiogram reports were reviewed to exclude right heart failure.

**Results:** Of the 87 total patients, venous outflow obstruction was confirmed in 27 (31%) based on sinusoidal congestion on pathology without presence of right heart failure. Of these 27 patients, 5 had detectable stenosis at venography (sensitivity, 19%; specificity, 100%) and demonstrated an increased pressure gradient between the right atrium and free hepatic vein compared to patients without visible stenosis ( $7.00 \pm 8.04$  and  $1.54 \pm 4.17$  mm Hg;  $P = .021$ ). In contrast, 13 of the 27 patients with sinusoidal congestion had a monophasic Doppler waveform (sensitivity, 48%; specificity, 88%) and also trended toward a larger pressure gradient compared to patients with a normal waveform ( $7.94 \pm 5.14$  and  $5.57 \pm 4.71$  mm Hg;  $P = .093$ ).

**Conclusions:** While hepatic venography has superb specificity for the diagnosis of hepatic vein stenosis, many cases of stenosis suspected on pathology do not manifest venographically. One hypothesis is that stenosis is a dynamic finding, and presence of a sheath or stiff wire may straighten the anatomy. Therefore, concurrent Doppler ultrasound may serve as a noninvasive test that may screen patients with hepatic venous outflow stenosis.

#### 2384546 Evaluation of Gastric Accommodation: Comparison of 3-Dimensional Ultrasound and Magnetic Resonance Imaging of Gastric Volumes

*Wijnand Buisman*

*Pediatric Surgery, University Medical Center Utrecht/ Wilhelmina Kinderziekenhuis, Amsterdam, the Netherlands*

**Objectives:** Gastric accommodation plays an important role in many clinical conditions. To investigate gastric accommodation, accurate measurements of gastric volumes are necessary. One of the techniques to measure gastric volumes is dynamic magnetic resonance imaging (MRI). Unfortunately, dynamic MRI is relatively expensive and not always available. A new 3D ultrasound (3D-US) method using a matrix transducer was developed to measure gastric volumes. In this study, we aim to compare the accuracy of our novel 3D-US method to dynamic MRI in gastric volume measurements.

**Methods:** A prospective study with 14 healthy adult volunteers, 6 men and 8 women with a median age of 27.2 years, was performed. All volunteers consecutively underwent dynamic MRI and a 3D-US of the stomach. An X6-1 Purewave xMatrix probe (Phillips) with a wide field of view and automated acquisition was used for 3D images. After an overnight fast, a 500-mL liquid test drink was distributed to the healthy volunteers, and 3 postprandial volume scans were performed. Gastric volumes were calculated with intragastric liquid content and total gastric volume (intragastric liquid content plus intragastric air). Accuracy of the 3D-US versus the dynamic MRI was evaluated according to Bland-Altman analysis.

**Results:** Mean postprandial liquid gastric content was 397 mL. Mean volume difference between the dynamic MRI and 3D-US was 1.0 mL with limits of agreement (LoA) of  $-8.9$  to  $10.9$  mL and a high intraclass correlation coefficient (ICC; 0.977). When gastric air was taken into account, mean postprandial total gastric volume (liquid + air) was 540 mL. The mean volume difference was 2.3 mL with LoA of  $-21.1$  to  $26.4$  mL and an ICC of 0.997. The mean volume difference and LoA in the total gastric volume measurements was significantly higher compared to the liquid gastric content measurements.

**Conclusions:** Matrix 3D-US showed excellent agreement with dynamic MRI in measuring gastric volumes, despite the negative influence of gastric air. Therefore, matrix 3D-US is a reliable alternative to measure gastric volumes, making assessment of gastric accommodation more accessible, fast, and less expensive.

#### 2385053 Characterization of Renal Angiomyolipomas by Quantitative Sonography

*Anil Chauhan,\* Laith Sultan, Peiman Habibollahi, Chandra Sehgal*

*Radiology, University of Pennsylvania, Philadelphia, PA USA*

**Objectives:** Angiomyolipomas (AMLs), the most common benign renal tumors, are typically echogenic on ultrasound, which obscures their differentiation from echogenic renal cell carcinomas. Consequently, biopsy rates and imaging follow-up for echogenic renal tumors continue to be high, while more than three-fourths of echogenic lesions are benign. The objective is to evaluate the efficacy of quantitative echo texture and echo intensity ultrasound features for differentiating renal AMLs from echogenic non-AML tumors.

**Methods:** Ultrasound images of 116 echogenic renal tumors were analyzed for tumor-to-cortex echo intensity ratios (TCER; the ratio of mean brightness values of the tumor and renal cortex) and computerized texture analysis. The reference standard was pathology, 2-year stability, or presence of macroscopic fat on computed tomography/magnetic resonance imaging. Texture measurements were derived from the absolute gradient, run length, and co-occurrence matrix. The features that showed a statistical difference were used with machine-learning algorithms involving logistic regression (LR) to determine class probability. The efficacy of the approach to differentiate AML from non-AML tumors was assessed by the area under the receiver operating characteristic curve (AUC).

**Results:** Of the 116 renal tumors, 88 (76%) were AMLs, and 28 (24%) were non-AMLs. TCER of AMLs was higher:  $4.4 \pm 3.3$  compared to  $2.2 \pm 0.7$  for the non-AML group ( $P < 10^{-7}$ ). Six of 21 texture features were statistically different for the 2 groups ( $P < .05$ ); 3 features were lower for AMLs (range, 0.97–1.94) compared to non-AMLs (range, 1.01–4.39), whereas the other 3 were significantly higher for AMLs (range, 0.86–1.05) compared to non-AMLs (range, 0.83–1.01). The AUC of the combined features using the LR method was  $0.91 \pm 0.03$  (sensitivity, 81.8; and specificity, 92.9), which outperformed each measurement individually, with AUC values of  $0.85 \pm 0.04$  for echo intensity and  $0.62 \pm 0.06$ – $0.79 \pm 0.05$  for echo texture parameters.

**Conclusions:** Quantitative analysis of renal tumors involving echo texture and echo intensity features combined with machine-learning methods improves differentiation of AMLs from other echogenic tumors. Further validation of these techniques could have a major impact on reducing biopsy and imaging follow-ups for echogenic renal tumors.

#### 2384147 Value of Contrast-Enhanced Ultrasound-Guided Percutaneous Biopsy in Anterior Mediastinum Lesions

*Yi Dong,\* Wen-Ping Wang, Feng Mao, Zheng-Biao Ji*

*Ultrasound, Zhongshan Hospital, Fudan University, Shanghai, China*

**Objectives:** To investigate the value of contrast-enhanced ultrasound (CEUS) in guidance of percutaneous biopsy in anterior mediastinum lesions.

**Methods:** The present study was approved by the Institutional Ethics Committee, and informed consent was waived. The study focused on 70 patients (male 48, female 22; mean age,  $43.5 \pm 6.3$  years) with 70 single anterior mediastinum lesions. All lesions were detected on contrast-enhanced computed tomography. Before biopsy, patients were randomly divided into a CEUS group ( $n = 35$ ) and a conventional ultrasound group ( $n = 35$ ). CEUS was performed with a C5-2 broadband curved transducer and an HD15 unit (Philips, Bothell, WA) in the CEUS group, with injection of 2.4 mL of SonoVue (Bracco, Italy). Coarse-needle (16-gauge) percutaneous biopsies were performed in all lesions. The display rate of interior necrotic areas and internal mammary arteries, biopsy success rate, and pathologic diagnosis rate were recorded.



**Results:** The mean maximum diameter of anterior mediastinum lesions was  $43.5 \pm 6.1$  mm (mean  $\pm$  SD). All lesions were proved by pathology as benign lesions ( $n = 6$ ), primary malignancies ( $n = 62$ ), or metastasis ( $n = 2$ ). In the CEUS group, 94.3% (33/35) lesions showed necrotic areas after SonoVue administration, which was higher than conventional ultrasound (54.3% [19/35];  $P < .05$ ). Internal mammary arteries were displayed in 57.1% (20/35) in the CEUS group, which were not obvious before CEUS. The sampling success rate and pathologic diagnosis rate of CEUS-guided biopsy (100% and 97.1%) were higher than the conventional ultrasound-guided group (90.4% and 81.7%;  $P < .05$ ).

**Conclusions:** CEUS before biopsy provided useful diagnostic information about anterior mediastinum lesions. By depicting interior necrotic areas and internal mammary arteries, it is a promising technique for guaranteeing the accuracy, success, and safety of coarse-needle biopsy.

#### 2379078 Ex Vivo Ultrasound Margin Assessment in Basal Cell Carcinoma: Initial Experience in 30 Cases

**Fernando Alfageme<sup>1</sup>,\* Eugenio Cerezo<sup>3</sup>, Lola Suarez<sup>2</sup>, Irene Salguero<sup>1</sup>, Rita Cabeza<sup>1</sup>, Gaston Roustán<sup>1,3</sup>**

<sup>1</sup>Dermatology, <sup>2</sup>Pathology, Hospital Universitario Puerta de Hierro, Majadahonda, Madrid, Spain; <sup>3</sup>Ecografía América, Madrid, Spain

**Objectives:** With this pilot study, we intended to explore the possibility of assessing basal cell carcinoma (BCC) specimens sonographically, comparing it with gold standard histologic margin evaluation.

**Methods:** Thirty consecutively excised BCC specimens were sonographically explored immediately after excision with an 18–22-MHz linear probe (Esaote, Geneva, Switzerland) attached to MyLab class C equipment. Exploration was performed, fixing the specimen to a bed of gauze with two 25-gauge needles and immersing in conventional ultrasound gel, leaving a 1-cm layer of gel over the specimen. The probe was protected with a sterile plastic cover to avoid contact of the probe with the fresh specimen. Scans of the whole specimens including the totality of lateral and deep margins were done, and both representative images and clips were acquired. Conventional histologic examination was performed for diagnostic confirmation, subtype classification, and lateral and deep specimen margin involvement. Sensitivity, specificity, positive predictive value, and negative predictive value of the sonographic evaluation of margin involvement in comparison with conventional histologic examination were calculated.

**Results:** Ex vivo ultrasound margin assessment (EVUSMA) was performed in 30 consecutive BCC specimens of 28 patients (9 female, 19 male). Mean age of the patients was  $75.4 \pm 5.3$  years, and locations of BCC were 21 in facial, head, and neck areas and 9 in the rest of the body surface. Mean maximum diameter of the lesions was  $10 \pm 2.3$  mm. With respect to BCC histologic subtype 7 were infiltrative, and 21 were expansive. EVUSMA was coincident with histologic free-margin diagnosis in both lateral and deep margins in 97.77% of the cases (29/30). False positives (5/30) were more frequent in lateral than in deep margin assessment (13.33% vs 3.33%). EVUSMA sensitivity and specificity for free margins were 97.77% and 86.66% for free lateral margins and 97.77% and 97.77% for deep margins.

**Conclusions:** EVUSMA in BCC is highly sensitive and specific for diagnosis of lateral and deep margin involvement. Further studies are needed to refine diagnostic features of the technique in other skin tumors.

#### 2345160 Study of Ultrasound-Guided Needle Aspiration and Catheter Drainage in the Management of Liver Abscesses

**Rohit Bhoil,\* Mukesh Surya, Y. P. Sharma**

Radiodiagnosis, Dr Rajendra Prasad Government Medical College, Kangra, India

**Objectives:** To evaluate and compare the efficacy of intermittent needle aspiration and continuous catheter drainage in the ultrasound-guided percutaneous treatment of liver abscesses.

**Methods:** This study was conducted on 50 patients (47 males and 3 females; age range, 22–74 years; average age, 40 years) with liver abscess(es) who were randomized into 2 groups: percutaneous needle aspiration (PNA;  $n = 25$ ) and percutaneous catheter drainage (PCD;  $n = 25$ ). In the aspiration group, pus was aspirated using an 18-gauge needle, and the number of aspiration attempts was limited to 2 times. Inability to achieve 50% reduction in abscess size on ultrasound or inability to achieve clinical relief after 2 attempts was considered as failure of aspiration. For catheter drainage, 10F or 12F catheters were introduced into the abscess cavity using the Seldinger technique. Drainage was treated as a failure if the abscess cavity did not resolve and laparotomy was needed to evacuate the pus cavity.

**Results:** The overall success rate in the PNA group in our study was 88%. In our study, PCD was successful in achieving a cure in 92% of patients; however, this difference was not statistically significant ( $P = .637$ ), suggesting that both PNA and PCD are equally efficacious. However, the total duration of the hospital stay was significantly less in the PNA group compared to the PCD group ( $P < .001$ ). The average duration between intervention and discharge was also significantly greater in the PCD group. Only 1 major complication was seen during our study: in the drainage group, 1 of the patients developed peritonitis due to a pericatheter leak. He was taken for emergency laparotomy. Recovery was uneventful.

**Conclusions:** We conclude that PNA in combination with antibiotics should be used as the first-line technique in the treatment of liver abscesses.

#### New Investigator Session

**Moderators: Phyllis Glanc, MDCM, BSc, FRCPR, Chandra Sehgal, PhD**

#### 2380144 Revisiting Cardiac Chamber Discrepancy in the Prenatal Diagnosis of Coarctation of the Aorta

**Suguna Ganesan<sup>1</sup>,\* Darren Hutchinson<sup>1,2</sup>, Bryn Jones<sup>1,2</sup>, Nicole Woodrow<sup>1</sup>**

<sup>1</sup>Pauline Gandel Imaging Center, Royal Women's Hospital, Brunswick, Victoria, Australia; <sup>2</sup>Pediatric Cardiology, Royal Children's Hospital, Parkville, Victoria, Australia

**Objectives:** Prenatal diagnosis of aortic coarctation remains one of the most challenging, with far-reaching consequences if not promptly recognized and managed. The purpose of this study was to assess the utility of fetal cardiac chamber size discrepancy as a reproducible finding when potentially considering fetal aortic coarctation in an otherwise normal midtrimester fetal cardiac study.

**Methods:** In this combined retrospective and prospective study, during the period of January 2013–December 2014, we identified 48 referrals requesting tertiary evaluation for isolated fetal cardiac chamber discrepancy between 18–26 weeks' gestation. Measurements of the mitral and tricuspid, aortic, and pulmonary valvular annuli, as well as across the aortic isthmus, were performed in all cases, and Z scores were calculated. Fetuses with chamber discrepancy due to right-sided hypoplasia, established hypoplastic left heart syndromes, and suspected aortic coarctation in conjunction with other major anomalies were excluded. Nineteen cases fitted the potential prenatal diagnosis of an isolated fetal coarctation of the aorta. Postnatal correlation with neonatal echocardiography as well as follow-up data were obtained.

**Results:** Our postnatal cohort confirmed aortic coarctation in 16/19 (84.1%). There were 3 (15.9%) false positives following postnatal assessment. No cases were missed prenatally. An associated bicuspid aortic valve was noted in a high proportion of patients (7/16 [43%]). A mean percentage difference of 26% (95% confidence interval [CI], 21.39–30.69) was noted between absolute dimensions of the mitral and tricuspid valves in confirmed cases of aortic coarctation. Although aortic isthmus Z scores  $\pm 2.4$  appeared more consistent with need for surgical intervention, they did not show statistical significance.

**Conclusions:** Standard cardiac screening views do not always include direct examination of the aortic arch to identify hypoplasia. Quantitative assessment of ventricular discrepancy (left < right) of greater than 25% (95% CI, 21.39–30.69) at the midtrimester scan appears to be a reproducible marker when attempting to identify an evolving isolated narrowing of the fetal aortic isthmus. The possibility of a bicuspid aortic valve also needs to be strongly considered in this patient group.

**2385462 High-Frequency Photoacoustic Characterization of Ex Vivo Lymph Nodes of Colorectal Cancer Patients**

*Emi Saegusa-Beecroft<sup>1</sup>, \*Ashwin Sampathkumar<sup>2</sup>, Jonathan Mamou<sup>2</sup>, Junji Machi<sup>1</sup>, Ernest Feleppa<sup>2</sup>*

<sup>1</sup>*Surgery, University of Hawaii and Kuakani Medical Center, Honolulu, HI USA;* <sup>2</sup>*Biomedical Engineering, Riverside Research, New York, NY USA*

**Objectives:** Quantitative photoacoustics (QPA) is an emerging modality that characterizes tissue based on tissue property estimates derived from spectrum analysis of photoacoustic (PA) radiofrequency (RF) signals and estimates derived from statistical analysis of the RF signal envelope. Our study seeks to employ QPA to distinguish cancerous from noncancerous regions of dissected lymph nodes (LNs) and hence to detect small, but clinically significant, cancerous foci that would be missed by current methods.

**Methods:** Dissected LNs were submerged in 0.9% saline, pinned through the perinodal fat layer to a sound-absorbing material, and scanned with our high-frequency PA data acquisition apparatus. A tunable laser was used to excite PA signals in the LN. A 26.2-MHz f2 transducer was scanned in the X-Y direction to acquire a complete 3D PA signal data set, which also was used to generate B-mode images. A calibrated power spectrum was computed from the PA signals, and linear regression was used to fit the resulting data to a straight line. The slope (dB/MHz) and absorber size (microns) were computed. A maximum-likelihood estimator was used to fit a Nakagami probability-density function (PDF) to the empirical PDF to produce a dimensionless parameter  $\mu N$ , which defines the number of microstructures per unit resolution cell.

**Results:** QPA analysis resulted in effective absorber sizes on the order of  $28.1773 \pm 4.2838$  microns, with a slope of  $0.1748 \pm 0.1619$  dB/MHz and a  $\mu N$  of  $0.9084 \pm 0.1596$  at 680 nm. The absorber size distribution was consistent with the PA contrast found in the B-mode image. The corresponding mean scatter size, slope, and  $\mu N$  for the processed region from ultrasound measurements were found to be  $26.0577 \pm 5.4970$  microns,  $0.2612 \pm 0.1681$  dB/MHz, and  $0.7201 \pm 0.0921$ , respectively.

**Conclusions:** The feasibility of using QPA for tissue characterization was demonstrated using dissected LNs. QPA tissue property estimates show promise for characterizing tissue and have the potential to provide molecular information for tissue constituents. Future studies will include blood volume and oxygen saturation maps that can greatly improve the estimates obtained from this preliminary QPA study.

**2388520 A Novel Semiautomated Fractional Limb Volume Tool for Rapid and Reproducible Fetal Soft Tissue Assessment**

*Lauren Mack<sup>1</sup>, \*Sung Yoon Kim<sup>2</sup>, Sungmin Lee<sup>3</sup>, Haleh Sangi-Haghpeykar<sup>1</sup>, Wesley Lee<sup>1</sup>*

<sup>1</sup>*Obstetrics and Gynecology, Baylor College of Medicine, Houston, TX USA;* <sup>2</sup>*Samsung Medison Research and Development Center, Seoul, Korea;* <sup>3</sup>*Samsung Medison Clinical Research Team, Seoul, Korea*

**Objectives:** To document the reproducibility and efficiency of a semiautomated image analysis tool that rapidly provides fetal fractional limb volume (FLV) measurements.

**Methods:** Fifty pregnant women underwent 3DUS scans at a mean menstrual age of 31.3 weeks for fractional arm (AVol) and thigh

(TVol) volumes. Manual or semiautomated FLV measurements were calculated using novel software (5D Limb Vol; Samsung Medison, Seoul, Korea). The software applies an image transformation method based on major axis length, minor axis length, and limb center coordinates. A transformed image is used to perform a global optimization technique for determination of an optimal limb soft tissue boundary. Bland-Altman analysis defined bias with 95% limits of agreement (LOA) between methods, and timing differences between manual versus automated methods were compared using a paired *t* test.

**Results:** Bland-Altman analyses indicate acceptable bias with 95% LOA between manual and semiautomated methods: AVol,  $1.7\% \pm 4.6\%$  (95% LOA,  $-7.3\%$  to  $10.7\%$ ); TVol,  $0.0\% \pm 3.8\%$  (95% LOA,  $-7.5\%$  to  $7.5\%$ ). Computer-assisted software completed measurements about 5 times faster when compared to manual tracings.

**Conclusions:** Semiautomated FLV measurements are significantly faster to calculate when compared to a manual procedure. These results are reproducible and are likely to reduce operator dependency. Addition of computer-assisted FLV to standard biometry may improve the precision of estimated fetal weight by adding a soft tissue component to the weight estimation process.

**2380297 Structure Function for Quantitative Ultrasound Tissue Characterization**

*Aiguo Han, \*William O'Brien Jr*

*University of Illinois at Urbana-Champaign, Urbana, IL USA*

**Objectives:** The backscattering coefficient (BSC) is a quantity that describes the ability of tissue to scatter ultrasound energy. It contains useful information about the tissue: it is related to the size and acoustic properties of individual scatterers (modeled by the form factor) and their spatial distribution (modeled by the structure function). Tissue parameters can be extracted from the BSC using an appropriate scattering model. Most models ignore the structure function. This study elucidates the relationship between structure function and the spatial distribution of scatterers by comparing ultrasound with histology.

**Methods:** The structure function was estimated independently from ultrasound and histology. Biophantoms were constructed by placing live cells of known concentration into coagulation media to form a clot. Three cell lines (Chinese hamster ovary, 13762 MAT B III, and 4T1) were used. The BSCs were estimated from 11 to 105 MHz. The structure function for a high-concentration (tissue-like) biophantom was isolated by comparing the BSC of the high-concentration biophantom with the BSC of a low-concentration biophantom (unity structure function) for the same cell line. Also, hematoxylin-eosin-stained histologic sections of dense cell pellet biophantoms were digitized. The scatterer positions were determined from the histologic images. The structure function was calculated from the extracted scatterer positions using 2-dimensional fast Fourier transform.

**Results:** The structure function obtained from histology showed reasonable agreement with that estimated from ultrasound. Fitting a polydisperse structure function model to the structure function yielded relatively accurate cell radius estimates. The relative error of cell radius estimates was less than 14% using the ultrasonically estimated structure function and less than 16% using the histologically estimated values.

**Conclusions:** The spatial distribution of scatterers is not negligible for scattering when the medium is dense. The ultrasonic data are related to the scatterer spatial distribution through the structure function. Accurate tissue parameters may be extracted from structure function using an appropriate model. (Supported by grants R01CA111289 and R01DK106419.)

### 2379335 Uterocervical Angle: A Novel Ultrasound Marker to Predict Spontaneous Preterm Birth

Margaret Dziadosz,\* Terri-Ann Bennett, Cara Dolin, Annie Honart, Sarah Lee, Sarah Pivo, Ashley Roman

New York University Langone Medical Center, New York, NY USA

**Objectives:** It has been proposed that pessary reduces risk of spontaneous preterm birth (sPTB) in high-risk women by mechanically altering the uterocervical angle (UCA). Performance of the UCS as measured by ultrasound for predicting sPTB is poorly understood. We examined whether a novel ultrasound marker, UCA, correlates with risk of sPTB.

**Methods:** This was a retrospective cohort study of singletons delivered at a single center from May 2014–May 2015. Demographic data and pregnancy outcomes were collected. Transvaginal ultrasound was performed during routine 2nd-trimester ultrasound (16–24 weeks). Cervical lengths (CLs) were recorded, and images of the lower uterine segment were obtained and remeasured for UCA between the lower uterine segment and the cervical canal. Receiver operating characteristic curves were developed to determine an optimal cutoff of UCA for prediction of sPTB <34 and <37 weeks. The primary outcome was prediction of sPTB by UCA. Data were evaluated using a  $\chi^2$  or Fisher exact test with  $P < .05$  as significant.

**Results:** A total of 972 women met inclusion criteria. Rates of sPTB in this cohort were 9.6% for delivery <37 weeks ( $n = 84$ ) and 4% for <34 weeks ( $n = 43$ ). UCA of  $>95^\circ$  is associated with sPTB <37 weeks with sensitivity of 80% ( $P < .001$ ; relative risk [RR], 4.3; confidence interval [CI], 0.702–0.811; specificity, 53%; positive predictive value [PPV], 14%; negative predictive value [NPV], 95%). UCA of  $>105^\circ$  predicted sPTB <34 weeks with sensitivity of 81% ( $P < .001$ ; RR, 7.2; CI, 0.719–0.853; specificity, 65%; PPV, 10%; NPV, 99%). Cervical length <2.5 cm predicted sPTB with sensitivity of 15% (specificity, 98%; PPV, 46%; NPV, 92%;  $P < .001$ ). Regression analysis revealed that there was a significant association of prior sPTB, dilation and curettage, cone, and obesity at conception with sPTB and UCA  $>95^\circ$  in this cohort. There was no correlation between race, abnormal pap smear results, smoking, and obesity at delivery on sPTB and UCA.

**Conclusions:** An obtuse UCA  $>95^\circ$  and  $>105^\circ$  detected during the 2nd trimester is associated with an increased risk for sPTB <37 and <34 weeks, respectively. UCA performed better than CL in identifying patients at increased risk of sPTB in this population. Our data suggest that UCA may be a useful, novel ultrasound marker predictive of sPTB.

### 2377746 Uterocervical Angle Measurement Improves Prediction of Cerclage Failure

Jordan Knight,\* Jessica Sheng, Frank Schubert, Avinash Patil

Obstetrics and Gynecology, Maternal-Fetal Medicine, Indiana University School of Medicine, Indianapolis, IN USA

**Objectives:** The anterior uterocervical angle has been used to measure the efficacy of cervical pessary placement for the prevention of preterm birth. Our objective is to evaluate the uterocervical angle as a predictor of preterm delivery in patients with a transvaginal cerclage.

**Methods:** A retrospective cohort of 59 women with transvaginal cerclage and evidence of cervical funneling were evaluated at a tertiary academic center from 2010–2015. Cervical morphologic characteristics (length, funnel volume, and uterocervical angle) were measured from endovaginal imaging of the cervix prior to cerclage placement (Angle 1), the first image after cerclage placement (Angle 2), and the last image prior to delivery (angle 3). Cerclage failure was defined as preterm delivery prior to 34 weeks. Pearson correlation, linear regression, and receiver operating characteristic (ROC) curves were used for statistical analysis using SPSS software. Statistical significance was defined as  $P < .05$ .

**Results:** Among the 59 women with transvaginal cerclage and evidence of funneling, the mean gestational age at birth was  $29.8 \pm 5.3$  weeks in the failure group ( $n = 29$ ) compared to  $38.1 \pm 1.4$  weeks in those that did not fail ( $n = 30$ ;  $P < .001$ ). Measurements (mean  $\pm$  SD) of angle 1, angle 2, and angle 3 were  $113.5^\circ \pm 11.02^\circ$ ,  $99.7^\circ \pm 8.59^\circ$ , and  $109.4^\circ \pm 10.97^\circ$ , respectively. The gestational age at birth correlated to angle 3 ( $R = -0.647$ ;  $P < .001$ ), cervical length ( $R = 0.478$ ;  $P < .001$ ), cervical funnel volume ( $R = 0.302$ ;  $P < .023$ ), and the interval change between angle 2 and angle 3 ( $R = -0.560$ ;  $P < .001$ ). A linear regression model consisting of cervical length and angle 3 was the most predictive of gestational age at birth ( $R^2 = 0.55$ ). ROC curves demonstrated improved prediction of delivery prior to 34 weeks with angle 3 (90% sensitivity, 71% specificity) vs cervical length (90% sensitivity, 51% specificity), and similarly prior to 28 weeks with angle 3 (93% sensitivity, 68% specificity) vs cervical length (93% sensitivity, 46% specificity).

**Conclusions:** In patients with transvaginal cerclage, a larger uterocervical angle increases the likelihood of cerclage failure. Uterocervical angle measurement may be an adjunct technique to identify patients at risk for cerclage failure and subsequent preterm delivery.

### 2382415 Comb-Push Shear Elastography on a Clinical Ultrasound Machine: First Report on Differentiation of Breast Masses

Mahdi Bayat<sup>1</sup>,\* Max Denis<sup>1</sup>, Adriania Gregory<sup>1</sup>, Mohammad Mehrmohammadi<sup>2</sup>, Duane Meixner<sup>3</sup>, Robert Fazzio<sup>3</sup>, Mostafa Fatemi<sup>1</sup>, Azra Alizad<sup>1</sup>

<sup>1</sup>Physiology and Biomedical Engineering, Mayo Clinic, Rochester, MN USA; <sup>2</sup>Wayne State University, Detroit, MI USA;

<sup>3</sup>Mayo Clinic, Rochester, MN USA

**Objectives:** To determine the performance of comb-push shear elastography (CUSE) on a clinical ultrasound machine (GE LOGIQ E9) in differentiation of breast masses when compared to pathologic results as the reference standard.

**Methods:** This study was done under an approved protocol by the Mayo Clinic Institutional Review Board. Female volunteers with suspicious breast masses on their clinical evaluation were selected for this study. A written signed informed consent was obtained from enrolled patients. Conventional ultrasound (US) and CUSE using GE's LOGIQ E9 machine with a 9L linear array probe were performed in 108 patients (mean age, 57.66 years; age range, 23–82 years) with 109 breast lesions (54 benign, 55 malignant; mean mass size, 16.40 mm); pathologic results were available in all cases. Quantitative lesion elasticity was measured in terms of the Young modulus (in kilopascals). The sensitivity, specificity, and area under the curve were obtained by using a receiver operating characteristic curve analysis to assess diagnostic performance.

**Results:** All 109 breast masses were identified by an expert sonographer, and 3 sequences of elastography were acquired as shear wave speed maps. Three 3-mm regions of interest (ROIs) were selected from inside the lesion area, which matched the borders on B-mode US. The average shear wave speed values from 3 ROIs were converted to the Young modulus. This number was found to be significantly higher in malignant masses than benign ( $93.02 \pm 34.9$  and  $28.02 \pm 22.08$  kPa, respectively). Comparing with pathology results and choosing an optimal differentiation threshold of 61.65 kPa resulted in 89.09% sensitivity (confidence interval [CI], 77.75%–95.89%), 94.44% specificity (CI, 84.6%–98.8%), and an area under the curve value of 0.93.

**Conclusions:** CUSE provides quantitative elasticity measurements with high sensitivity and specificity in differentiating between malignant and benign breast masses, thus adding the complementary information that potentially could help in breast lesion characterization using US.



### 2347629 Effect of Fabrication Methods on the Acoustic Properties of Encapsulated Oxygen Microbubbles

**Rawan Shraim<sup>1,2</sup>,\* Margaret Wheatley<sup>1</sup>, Patrick O'Kane<sup>2</sup>, Flemming Forsberg<sup>2</sup>, John Eisenbrey<sup>2</sup>**

<sup>1</sup>School of Biomedical Engineering and Health Sciences, Drexel University, Philadelphia, PA USA; <sup>2</sup>Radiology, Thomas Jefferson University, Philadelphia, PA USA

**Objectives:** The delivery of oxygen to hypoxic tumors through microbubbles is expected to aid in radiotherapy sensitization. This study compares how different shell materials and primary fabrication gasses influence encapsulation and acoustic properties of oxygen microbubbles.

**Methods:** Different freeze-dried microbubbles were tested: the first (A), originally containing sulfur hexafluoride (SF<sub>6</sub>), had a phosphatidylserine shell; the second (B) was composed of galactose microparticles and palmitic acid (PA) from an air core; the third (C), from a perfluorocarbon (PFC) bubble, had a mixed phospholipid/PA shell with a polyethylene glycol stabilizer; and the fourth (D) consisted of a surfactant combined with a water-soluble vitamin E shell originally containing PFC. After removal of the primary filling gas, oxygen was introduced into the microbubble vials under vacuum. The formulation with the highest acoustic enhancement was further tested by comparing PFC and SF<sub>6</sub> as primary fabrication gasses. In vitro acoustic testing was completed in a tank setup with a single-element 5-MHz transducer (0.45 MPa peak negative pressure with a pulse repetition frequency of 100 Hz). The temperature within the tank was 37°C, and the sample was continuously stirred. Enhancement as a function of dosage was compared between the microbubbles. The half-life of the SF<sub>6</sub> and PFC microbubbles was also compared.

**Results:** The average peak enhancement values for microbubbles A, B, C, and D were 2.8 ± 2.5, 5.0 ± 1.5, 5.0 ± 1.1, and 17.0 ± 1.0 dB, respectively ( $P < .0001$ ). When comparing fabrication gasses, the peak enhancement values of the PFC- and SF<sub>6</sub>-charged microbubbles were 15.1 ± 1.4 and 8.6 ± 1.9 dB ( $P < .0001$ ), while the half-life values were 6.1 ± 1.6 and 0.76 ± 0.2 minutes ( $P < .0001$ ).

**Conclusions:** Microbubbles composed of a surfactant/vitamin E shell appear to be superior at encapsulating oxygen compared to microbubbles with lipid or galactose shells. In addition, using PFC as the primary filling gas resulted in superior oxygen microbubbles when compared to SF<sub>6</sub>. Thus, formulation D initially fabricated with PFC appears suitable for future therapeutic oxygen delivery applications in vivo.

### 2384956 Comparison of 3-Dimensional Strain Volume Reconstructions Using Sheaf of Ultrasound Planes Reconstruction- and Wobbler-Based Acquisitions

**Wenjun Yang<sup>1</sup>,\* Atul Ingle<sup>2</sup>, Tomy Varghese<sup>1</sup>**

<sup>1</sup>Medical physics, University of Wisconsin, Madison, WI USA; <sup>2</sup>Fitbit, Boston, MA USA

**Objectives:** To compare 3D reconstruction of ultrasound strain imaging using a conventional Wobbler transducer and our previously developed sheaf of ultrasound planes reconstruction (SOUPR).

**Methods:** Three-dimensional strain volume reconstructions were performed on a single-inclusion tissue-mimicking phantom. The Wobbler transducer provides quasiparallel imaging planes with a 2-mm separation. At each imaging plane, a 2% quasistatic compression with respect to the phantom height was applied to obtain 2D strain images with a 2D cross-correlation-based deformation-tracking algorithm. Eight different cross-correlation kernels with axial dimensions ranging from 3.4–7.5 wavelengths and 3–7 A-lines were evaluated. These 2D strain images were reconstructed using a bicubic interpolation into a 3D volume. The same processing parameters were applied for SOUPR except that the imaging planes acquired were rotated over a 30° interval, with the reconstruction algorithm formulated as an optimization problem with constraints on data consistency and smoothness. Reconstructed inclusion volumes, shapes, signal-to-noise ratio (SNR), and contrast-to-noise ratio (CNR)

were compared between SOUPR and Wobbler acquisitions for 10 independent experimental realizations for each kernel size. Validation of SOUPR and Wobbler reconstruction was also performed using a thermally ablated region created in ex vivo bovine liver tissue.

**Results:** Inclusion volume estimates were in a similar range for both acquisition approaches. The SNR and CNR obtained with SOUPR, however, were significantly higher: on the order of 250% and 166%, respectively. The mean square error of the reconstructed inclusion dimensions using a Wobbler was significantly higher: on the order of 1300% and 386% along the x- and z-axes, respectively.

**Conclusions:** Improved 3D strain volume reconstructions were obtained with SOUPR when compared to a conventional Wobbler transducer-based method for an ellipsoidal inclusion, which is common for tumor and ablated region geometries. (Funded by National Institutes of Health grant 2R01 CA112192.)

### 2381525 Monitoring Microwave Ablation Treatments for Hepatocellular Carcinoma Using Electrode Displacement Elastography

**Wenjun Yang<sup>1</sup>,\* Marci Alexander<sup>2</sup>, Kelly Wergin<sup>2</sup>, Nicholas Rubert<sup>1</sup>, Atul Ingle<sup>3</sup>, Meghan Lubner<sup>2</sup>, Timothy Ziemlewicz<sup>2</sup>, James Hinshaw<sup>2</sup>, Shane Wells<sup>2</sup>, Fred Lee Jr<sup>2</sup>, James Zagzebski<sup>1</sup>, Tomy Varghese<sup>1</sup>**

<sup>1</sup>Medical Physics, <sup>2</sup>Radiology, University of Madison, Madison, WI USA; <sup>3</sup>Fitbit, Boston, MA USA

**Objectives:** To evaluate electrode displacement elastography (EDE) for monitoring microwave ablation (MWA) treatments for patients with hepatocellular carcinoma (HCC).

**Methods:** We evaluated EDE on 46 patients diagnosed with HCC who were treated with a minimally invasive MWA procedure. MWA was performed using a Neuwave Medical (Madison, WI) Certus 140 system with a single or multiple antennas. EDE was applied after the MWA procedure, with the local tissue deformation imparted by manual perturbation of one of the ablation antennas by the clinician. Radiofrequency (RF) data loops were acquired during the perturbation using a Siemens S2000 ultrasound system with a 6C1 curvilinear transducer. Local tissue displacements were tracked from 2 RF frames with a 2D cross-correlation-based algorithm. Corresponding strain images were constructed by calculating and displaying gradients of these displacements. Maximum length, area, contrast, and contrast-to-noise ratio (CNR) of the treated regions depicted on EDE images were compared to analogous measures on conventional ultrasound B-mode images.

**Results:** The ablated region could be identified on EDE images of 41 of the 46 patients. The average maximum length of the ablated region for the 41 patients was estimated to be 4.37 ± 0.91 cm on EDE, while the average length judged from B-mode images was 3.32 ± 0.86 cm. The average ablated region area with EDE was 13.38 ± 4.99 cm<sup>2</sup>, compared to 7.61 ± 3.21 cm<sup>2</sup> seen on B-mode images. Contrast and CNR of ablations depicted on EDE were significantly higher than values measured from B mode images: on the order of 132% and 252%, respectively. The  $P$  values of these comparisons were <.001.

**Conclusions:** EDE is a potential alternative for real-time monitoring of the MWA procedure for patients with HCC. (Funded by National Institutes of Health grant 2R01 CA112192.)



### 2383721 Effect of Percutaneous Ultrasound-Guided Subacromial Bursography With Microbubbles for Assessment of Rotator Cuff Tears

Xueqing Cheng

Ultrasound, Sichuan Academy of Medical Sciences and Sichuan Provincial People's Hospital, Chengdu, Sichuan, China

**Objectives:** The purpose of this study was to determine the feasibility and the value of percutaneous ultrasound-guided subacromial bursography (PUSB) with contrast-enhanced ultrasound (US) for assessment of rotator cuff tears.

**Methods:** Between January 2012 and September 2014, 2D US and PUSB were prospectively performed in 135 patients with suspected rotator cuff tears from among 2169 patients with clinically diagnosed subacromial impingement syndrome. Sixty-three patients who had undergone arthroscopy were included. The PUSB findings were compared with those from 2D US using the McNemar test, with arthroscopy as a standard.

**Results:** Of a total of 19 full-thickness tears (FTTs), 2D US correctly diagnosed 12 and PUSB correctly diagnosed 18 ( $P = .031$ ). With regard to partial-thickness tears, 2D US correctly diagnosed 31 and PUSB correctly diagnosed 35 of a total of 41 tears ( $P = .375$ ). Accuracy in diagnosing FTTs was 81.0% for 2D US and 98.4% for PUSB. 2D US and PUSB yielded sensitivity of 63.2% and 94.7%, respectively, for full-thickness tears, with specificity of 88.6% and 100.0%, respectively.

**Conclusions:** PUSB is a safe and feasible procedure, with greater sensitivity and specificity than 2D US in diagnosing FTTs. As such, PUSB improves the value of ultrasound for assessing rotator cuff pathology.

### 2384897 Recipient Umbilical Artery Elongation in Twin-Twin Transfusion Syndrome

Roopali Donepudi<sup>1,3,\*</sup>, Lovepreet Mann<sup>1,3</sup>, Christoph Wohlmuth<sup>2</sup>, Kenneth Moise<sup>1,3</sup>, Saul Snowise<sup>1,3</sup>, Yisel Morales<sup>1,3</sup>, Anthony Johnson<sup>1,3</sup>, Michael Bebbington<sup>1,3</sup>, Helena Gardiner<sup>1,2,3</sup>, Ramesha Papanna<sup>1,3</sup>

<sup>1</sup>Obstetrics and Gynecology, <sup>2</sup>Pediatric Cardiology, UT Health, University of Texas Medical School, Houston, TX USA;

<sup>3</sup>Obstetrics and Gynecology, The Fetal Center, Children's Memorial Hermann Hospital, Houston, TX USA

**Objectives:** Chronic hypertension causes arterial elongation in systemic arteries through arterial stretching. Recipient fetus's changes in twin-twin transfusion syndrome (TTTS) include hypertension and hypervolemia, but the effect of increased intravascular pressure and volume on umbilical vessels is unknown. We tested the hypothesis that the recipient umbilical artery (UA) increases in length relative to its vein compared to controls.

**Methods:** Prospective study comparing two groups: TTTS patients undergoing laser surgery and gestational age-matched controls. A preoperative 3D color Doppler volume image of a 5-cm segment of the umbilical cord was obtained. Quantitative assessment of the angle of inclination between the UA and umbilical vein (UV) was performed by a 2-line angle method. The ratio of the UA to UV length (AVI) was obtained by tracing the vessels within the same cord segment. Correlation of AVI to the stage of disease and UA Doppler indices was performed.

**Results:** A UA-to-UV angle of  $\geq 26^\circ$  (above 95th percentile for control) was seen in 54% of recipient cords. The UA-to-UV angle and AVI significantly correlated ( $R^2 = 0.74$ ;  $P < .0001$ ). Stages II and III had significantly higher AVI ( $P = .04$ ) and angle ( $P < .001$ ) compared to controls. Among TTTS cases, the AVI for stage IIIR ( $1.8 \pm 0.57$ ) was significantly higher than the remaining recipients ( $1.4 \pm 0.43$ ;  $P = .04$ ). Linear regression showed that an increasing UA pulsatility index (PI) was associated with increased AVI ( $P = .027$ ), while the systolic/diastolic ratio and resistance index were not significant. Inter-rater and intra-rater agreements for AVI and UA-to-UV angle were 0.95 ( $\kappa$  statistics,  $P = .04$ ).

**Conclusions:** The umbilical arterial length is increased in 54% of recipients and associated with increased UA PI. This may reflect chronicity and the severity of hypertension in the recipient. Further research is needed to explore the mechanisms of elongation and its implications for cardiovascular health during adult life.

Table 1. Recipient Versus Healthy Controls

	Recipient (n = 28)	Control (n = 20)	P
Gestational age at ultrasound, wk	20.2 $\pm$ 2.5	21.1 $\pm$ 1.7	.16
Estimated fetal weight, g	386.5 $\pm$ 199	434.3 $\pm$ 140.8	.36
UA-to-UV angle	34.6° $\pm$ 30°	8.8° $\pm$ 7.7°	<.001
AVI	1.5 $\pm$ 0.48	1.1 $\pm$ 0.1	<.001

### Obstetric Ultrasound: New Techniques

Moderator: Jude Crino, MD

### 2376552 HDlive Silhouette Mode in Antenatal Diagnosis of Intestinal Abnormalities

Mohamed AboEllail<sup>1,2,\*</sup>, Kenta Yamamoto<sup>1</sup>, Megumi Ishibashi<sup>1</sup>, Masato Mashima<sup>1</sup>, Hirokazu Tanaka<sup>1</sup>, Toshiyuki Hata<sup>1</sup>

<sup>1</sup>Perinatology and Gynecology, Kagawa University School of Medicine, Miki, Kagawa, Japan; <sup>2</sup>Obstetrics and Gynecology, Sohag University, Sohag, Egypt

**Objectives:** We present our experience with normal fetal gastrointestinal tract (GIT) and congenital intestinal abnormalities reconstructed using the HDlive silhouette mode.

**Methods:** Three normal fetuses and 5 fetuses with GIT abnormalities (1 case each of meconium peritonitis [MP], a diaphragmatic hernia, and an enteric duplication cyst, and 2 of jejunal atresia/stenosis) at 17–36 weeks' gestation were included.

**Results:** In normal fetuses, clear visualization of the stomach with its position on the left side below the heart was achieved at 17 weeks. Spatial relationships among the stomach and surrounding structures such as the heart, diaphragm, descending aorta, and spine can be achieved at 23 weeks 6 days. At the same age, detailed demonstration of stomach parts (fundus, body, and pylorus) was made. A panoramic ventral view of the fetal GIT was depicted at 36 weeks 4 days, where the stomach, ascending colon, hepatic flexure, transverse colon, splenic flexure, and descending colon were displayed in the same scanning plane, identical to normal anatomy. In MP, the inner wall of the dilated intestinal loops with different caliber changes was demonstrated. In the diaphragmatic hernia, the stomach and heart were both seen at the same level above the clearly visualized diaphragm. In the enteric duplication cyst, its wall appeared to be thick with opacities representing the debris inside it at 33 weeks. In jejunal atresia, the dilated stomach was seen located behind the dilated duodenum. The atretic proximal part of the jejunum was demonstrated. Spatial relationships among the stomach, duodenum, and jejunum and the delineation of their outer contour enabled localization of the lesion. The propagation of the peristaltic wave in different parts of the GIT was easily judged by changes in its caliber at 28 weeks. Moreover, the spine as an anatomic landmark for the back and umbilical vein for the front in jejunal stenosis were evident at 28 weeks 4 days.

**Conclusions:** Accurate evaluation of the fetal GIT from the inside as well as its outer contour, the peristaltic wave, and the relationship with surrounding structures represent the main prospective use of the HDlive silhouette mode. This technique provides more a comprehensive, detailed view of different parts of the fetal GIT, which might be beneficial in diagnosing and differentiating fetal GIT abnormalities.

**2362569 Fetal Adrenal Gland Size and Ability to Predict Spontaneous Term Labor****Alexis Gimovsky<sup>1</sup>, \* Matthew Hoffman<sup>2</sup>, Philip Shlossman<sup>2</sup>**<sup>1</sup>Obstetrics and Gynecology, Division of Maternal-Fetal Medicine, Sidney Kimmel Medical College at Thomas Jefferson University, Philadelphia, PA USA; <sup>2</sup>Obstetrics and Gynecology, Christiana Care Health System, Newark, DE USA

**Objectives:** Fetal adrenal size has been shown to be predictive of spontaneous preterm birth. The objective of this study was to evaluate whether ultrasound-measured fetal adrenal gland size predicts spontaneous labor.

**Methods:** Prospective cohort study using 2-dimensional ultrasound to measure fetal adrenal gland total length, total width, fetal zone length, and fetal zone width in women presenting for a biophysical profile at 36–42 weeks gestational age. The ratio of total fetal gland width (W) and fetal zone width (w) was used to control for fetal weight. The ability of w/W and other fetal adrenal measurements was evaluated for prediction of spontaneous labor. Exclusion criteria were: known scheduled cesarean delivery, receiving 17- $\alpha$ -hydroxyprogesterone, cerclage, fetal anomalies, planned preterm delivery, known uterine anomaly, multiple pregnancy, fetal growth restriction, and polyhydramnios.

**Results:** Forty-three patients were recruited: 11 (27.5%) presented in spontaneous labor. Secondary outcomes were vaginal delivery (n = 31 [77.5%]), length of labor, and maternal and neonatal morbidities. Three patients were excluded for adrenal gland unable to be measured (n = 1), primary cesarean without labor on presentation for induction (n = 1), and breech presentation and subsequent primary cesarean delivery (n = 1). Patient demographics were similar except for cervical exam at the time of admission and oxytocin use. A receiver operating characteristic curve was created to assess differing fetal adrenal gland measurements as a test for predicting spontaneous labor. w/W was the best predictor of spontaneous labor among variables measured, with an area under the curve of 0.674 ( $P = .93$ ). w/W  $\geq 0.41$  had a sensitivity of 91.0%, specificity of 44.8%, positive predictive value of 38.5%, and negative predictive value of 92.3% for predicting spontaneous labor. Maternal and neonatal morbidities were not different between groups.

**Conclusions:** Ultrasound-measured fetal w/W was moderately predictive of spontaneous labor in this small prospective cohort.

**2380504 Elastography of the Postpartum Perfused Human Placenta**  
**Stephen McAleavey<sup>2</sup>, Kevin Parker<sup>1</sup>, \* Juvenal Ormachea<sup>1</sup>, Ronald Wood<sup>3</sup>, Christopher Stodgett<sup>3</sup>, Philip Katzman<sup>4</sup>, Richard Miller<sup>3</sup>**<sup>1</sup>Electrical and Computer Engineering, <sup>2</sup>Biomedical Engineering, University of Rochester, Rochester, NY USA; <sup>3</sup>Obstetrics and Gynecology, <sup>4</sup>Pathology and Laboratory Medicine, University of Rochester Medical Center, Rochester, NY USA

**Objectives:** Elastography is well established in a number of organs. However, the biomechanical properties of the normal placenta have not been studied extensively. Recently, Cimsit (2015) demonstrated a potential use of placental elastography to predict preeclampsia. Many unresolved issues remain for elastography in the human placenta, including the range of normal values, possible dependence on physiologic variables such as fetal blood pressure and flow, and the results of specific pathologies. This study aims at providing initial estimates of placenta stiffness under a range of experimental conditions.

**Methods:** Eight human term placentas were obtained postpartum. The umbilical arteries and vein were catheterized using 5F umbilical catheters as previously described (Miller, 1985, 1993). Hemodynamic control consisted of instantaneous pressure readings with recordings every 5 seconds and maintenance of fetal arterial flow at 3 mL/min. Placental elastographic images were generated using a Siemens Antares scanner and VF10-5 probe at 5 MHz with our custom single-track-location shear wave

elasticity imaging (STL-SWEI) pulse sequences and graphics-processing unit-accelerated processing (McAleavey, 2009). Placentas were placed on an acoustically absorbing pad, immersed in a buffered saline bath at 35°C and scanned during perfusion, during a pause in perfusion, and following the injection and setting of a barium/agar solution. Color and Doppler spectral signals were obtained after injection of Optison (GE Medical Imaging).

**Results:** Placental elastographic measurements can be acquired in near real time using a Siemens scanner and advanced STL-SWEI. Shear wave speeds for normal parenchyma on the fetal side are on the order of those measured in soft liver ( $\approx 2$  m/s). Shear wave speeds in the placenta are measurably increased by abnormalities, including infarcts and artificial “clots” introduced by perfusing viscous gelatin solutions into the vasculature. Fetal flow and pressure can modify tissue stiffness.

**Conclusions:** Elastography of human placentas will provide a useful clinical tool for discriminating normal vs abnormal regions. Future work includes a determination of the range of normal placental shear wave speed vs gestational age.

**2380956 Uterocervical Angle: A Novel Ultrasound Marker to Assess Risk for Spontaneous Preterm Birth in Twins****Margaret Dziadosz<sup>\*</sup>, Terri-Ann Bennett, Cara Dolin, Annie Honart, Sarah Lee, Sarah Pivo, Ashley Roman**

New York University Langone Medical Center, New York, NY USA

**Objectives:** Spontaneous preterm birth (sPTB) has multiple etiologies and poorly defined pathophysiology. It is significantly more common in multiple gestations. Alterations to the uterocervical angle (UCA) have been proposed as a method to reduce sPTB through mechanical support via pessary. We examined whether a novel ultrasound marker, UCA, correlates with sPTB in twins.

**Methods:** This was a retrospective cohort study of deliveries at a single center from May 2014–May 2015. Demographic data and pregnancy outcomes were collected. Transvaginal ultrasound was performed during routine 2nd-trimester ultrasound (16–24 weeks). Cervical lengths (CLs) were recorded, and images of the lower uterine segment were obtained and remeasured for UCA between the lower uterine segment and the cervical canal. Receiver operating characteristic curves were developed to determine an optimal cutoff of UCA for prediction of sPTB <37 weeks for twin gestations. The primary outcome was prediction of sPTB by UCA. Data were evaluated using a  $\chi^2$  or Fisher exact test with  $P < .05$  as significant.

**Results:** A total of 1109 women met inclusion criteria. Forty-one twin gestations were identified, and 28 met inclusion criteria for sPTB. The rate of sPTB in this cohort was 42% for delivery <37 weeks (n = 12). UCA of  $>95^\circ$  is significantly associated with sPTB <37 weeks, with sensitivity of 82% ( $P < .001$ ; specificity, 46%; positive predictive value [PPV], 73%; negative predictive value [NPV], 92%). No UCA was identified to predict sPTB at earlier gestational ages. Cervical length <2.5 cm did not predict sPTB (sensitivity, 8%; specificity, 93%; PPV, 50%; NPV, 57%). Regression analysis revealed that there was no correlation between race, history of PTB, abnormal pap smear results, cervical surgery, mode of delivery, smoking, and obesity at delivery on sPTB and UCA.

**Conclusions:** An obtuse UCA  $>95^\circ$  detected during the 2nd trimester is associated with an increased risk for sPTB <37 weeks in twin gestations. UCA performed better than CL in identifying at-risk patients in this cohort. Our data suggest that UCA may be a useful, novel ultrasound marker predictive of sPTB in twin gestations.

**2381556 Effect of Preeclampsia on Umbilical Vein Blood Volume Flow in a Limited Cohort**Stephen Pinter<sup>1</sup>, \* Oliver Kripfgans<sup>1</sup>, Marjorie Treadwell<sup>2</sup>, Anna Kneitel<sup>2</sup>, J. Brian Fowlkes<sup>1</sup>, Jonathan Rubin<sup>1</sup><sup>1</sup>Radiology, <sup>2</sup>Obstetrics and Gynecology, University of Michigan, Ann Arbor, MI USA

**Objectives:** Measurement of umbilical vein blood volume flow in normal and preeclamptic maternal subjects using a 3D/4D sonographic method that is independent of traditional pulsed wave Doppler flow limitations and assumptions: eg, beam-to-flow angle, vessel diameter, and vessel flow profile.

**Methods:** A GE LOGIQ E9 ultrasound system and RAB6-D transducer (2.0–8.0 MHz) were used to acquire multivolume 3D/4D color and power Doppler data. Volumetric flow was computed offline via a user-specified focal c-surface (lateral-elevational) with surface integration of Doppler-measured velocity vectors. Power Doppler data were used to eliminate partial volume effects. Under Institutional Review Board approval, a cohort of 8 normal subjects (singletons; gestation 25.9–34.7 weeks) and 5 preeclamptic subjects (singletons; gestation 29.7–34.3 weeks) were recruited from the University of Michigan Medical Center High-Risk Obstetrics Clinic. Subjects were followed full term, and outcomes were verified. For each subject, average umbilical vein flow was determined from 3 different positions along the cord. Flow measurements were computed using an average of  $28 \pm 2$  (mean  $\pm$  SD) volumes, and estimates were depth corrected. Weight-normalized flow was computed using the 50th percentile weight (Hadlock et al, *Radiology* 1991; 181:129–133). Cohorts were compared based on absolute flow (mL/min) and normalized flow (mL/min/kg) using an unpaired *t* test.

**Results:** Absolute flow was  $177.5 \pm 21.5$  and  $155.5 \pm 7.5$  mL/min (mean  $\pm$  SE) in the normal and preeclamptic cohorts, respectively, with moderate separation between groups ( $P = .36$ ). Weight-normalized flow was  $96.2 \pm 7.6$  and  $74.1 \pm 4.6$  mL/min/kg (mean  $\pm$  SE) in the normal and preeclamptic cohorts, respectively, with a statistically significant difference ( $P = .032$ ).

**Conclusions:** Results indicate that weight-normalized umbilical vein blood flow is reduced in preeclamptic subjects and encourage further studies in a larger clinical population. Volume flow measurement with 3D/4D sonography may provide a complementary diagnostic metric to manage at-risk pregnancies. (This work was supported by the AIUM Endowment for Education and Research (Samsung Medison America). Volume flow is under development by the Quantitative Imaging Biomarkers Alliance.)

**2384611 The Role of the First-Trimester Maxillary Gap in a Series of 4 Cases in Lebanon**Reem Abu-Rustum<sup>1</sup>, \* Nabil Helou<sup>2</sup>, M. Fouad Ziade<sup>3</sup><sup>1</sup>Center for Advanced Fetal Care, Tripoli, Lebanon; <sup>2</sup>Radiology, Aboujaoude Hospital, Jal El Dib, Lebanon; <sup>3</sup>Faculty of Pubic Health, Lebanese University, Tripoli, Lebanon

**Objectives:** The maxillary gap (MxG) has recently been described as a first-trimester marker for cleft lip and palate (CLP). As such, we sought to assess its role in our population.

**Methods:** This was a retrospective study carried out by 2 experienced sonologists (R.A.R. and N.H.) on 20 first-trimester fetuses: 4 confirmed cases of CLP each matched with 4 normal controls. There were stored volume data sets on all cases. Outcome was available on all fetuses. R.A.R. retrieved the midsagittal plane for all 20 cases, assessed the images for the MxG, measured it when present, and then deidentified, cropped, and mixed all images. Images were sent for offline analysis to N.H., who was completely blinded to the outcome and the number of affected cases. N.H. was asked to identify the cases with an MxG. The data were analyzed using a Student *t* test.  $P < .05$  was considered significant.

**Results:** The mean crown-rump length was 67.85 mm in the controls and 68.53 mm in the affected fetus ( $P = .87$ ). The mean nuchal

translucency was 1.78 mm in the controls and 1.7 mm in the affected fetuses ( $P = .65$ ). Of the 4 cases of CLP, 1 was isolated unilateral, 1 was isolated bilateral, 1 was unilateral with multiple anomalies, and 1 was bilateral with multiple anomalies. The MxG was clearly identified by both sonologists in all 4 cases. The MxG measured  $>1.5$  mm in all 4 cases with CLP. There were no false-positive cases noted by either reviewer.

**Conclusions:** Even in this small cohort of patients, our study attests to the feasibility of visualizing the MxG and its clinical utility as a new first-trimester marker in the early screening for CLP. Incorporating the MxG into first-trimester screening may enhance the sensitivity for early detection of CLP. However, larger prospective studies are needed to assert its role prior to routine incorporation into the first-trimester anatomy scan.

**2384672 The Role of Adjunct Ultrasound Parameters During Antepartum Testing: The Doppler Cerebroplacental Ratio Versus the Amniotic Fluid Deepest Vertical Pocket**Kareem Tabsh<sup>1</sup>, \* Wanchi Zeng<sup>1</sup>, Gregory DeVore<sup>2,3</sup><sup>1</sup>Obstetrics and Gynecology, Kern Medical Center, Bakersfield, CA USA; <sup>2</sup>Fetal Diagnostic Center, Pasadena, CA USA; <sup>3</sup>Obstetrics and Gynecology, David Geffen School of Medicine at UCLA, Los Angeles, CA USA

**Objectives:** Evaluate the role of ultrasound measurement of the deepest vertical pocket (DVP) vs the cerebroplacental ratio (CPR) in fetuses undergoing antepartum testing.

**Methods:** The antepartum testing records of 534 women who underwent antepartum testing were retrospectively reviewed between 2009 and 2013. All patients underwent a nonstress test, measurement of the DVP, and Doppler evaluation of the resistance index (RI) of the middle cerebral artery (MCA) and umbilical artery (UA). The CPR was computed as follows: RI of the MCA/RI of the UA, with a value  $<1$  considered abnormal. A DVP  $<2$  cm was considered abnormal. The patients were divided into 2 groups at the time of their last antepartum test based on the recommendation of the maternal-fetal medicine specialist: continuation of the pregnancy or recommendation for delivery. The gestational ages of the fetuses evaluated were between 36 and 41 weeks.

**Results:** Of the 534 pregnancies, recommendations were made for delivery in 23.6%. There were no significant differences in the DVP between those who continued the pregnancy and those in whom delivery was recommended (Table 1). There were no significant differences in the CPR between those who continued the pregnancy and those in whom delivery was recommended for gestational ages between 36 and 38 weeks 6 days. However, in pregnancies at 39 weeks and greater, there was a significant difference ( $P < .05$ ) between those with an abnormal CPR in whom delivery was recommended (13%) vs those in whom continuation of the pregnancy was recommended (2.5%).

**Conclusions:** The CPR has recently been shown to be a predictor of adverse perinatal and neonatal outcomes. This retrospective study demonstrates that the CPR identified fetuses in whom recommendations were made for delivery at 39 weeks of gestation and greater. Therefore, while the clinician may utilize the DVP as part of antepartum assessment, the CPR may be a useful measurement from 39 weeks onward in evaluating the high-risk fetus.

Table 1

Weeks of Gestation	36–36+6	37–37+6	38–38+6	38–41
DVP (no delivery vs delivery)	0% vs 0%	0.95% vs 3.8%	0.8% vs 4.3%	1.2% vs 3.1%
CPR (no delivery vs delivery)	6.35% vs 11%	5.1% vs 0%	6.2% vs 12%	2.55% vs 13% ( $P < .05$ )



### 2384939 The Value of Second-Trimester Crown-Rump Length Measurement in the Diagnosis of Skeletal Dysplasia

Karla Leavitt<sup>1,2</sup>, \* Alberto de la Vega<sup>1</sup>, Komal Bajaj<sup>2</sup>

<sup>1</sup>Obstetrics and Gynecology, University of Puerto Rico School of Medicine, San Juan, PR USA; <sup>2</sup>Obstetrics and Gynecology, Division of Reproductive Genetics, Montefiore Medical Center, Bronx, NY USA

**Objectives:** The first aim of this study was to establish a normogram of second-trimester crown-rump length (CRL). This normogram was then applied to aid in the detection of spondylocostal dysostosis.

**Methods:** This was a prospective cross-sectional continuous selection done at a tertiary center, with subjects between 13 and 25 weeks of gestation to develop the normograms for CRL. Patients with uncertain gestational age, abnormal ultrasound findings, multifetal pregnancy, or maternal conditions that may affect fetal growth, such as diabetes, hypertension, autoimmune disease, or teratogenic exposure, were excluded. Data obtained were used to create fetal growth curves and the establish the 5th, 50th, and 95th percentiles. The fetuses suspected of having spondylocostal dysostosis and later confirmed postnatally had CRL measurements during the second trimester.

**Results:** A total of 1157 normal fetuses from 13–25 weeks were included in this study. The CRL of all 14 cases of spondylocostal dysostosis were found to be significantly below the 5th percentile for the normal population and to also maintain a linear growth pattern.

**Conclusions:** All 14 fetuses with postnatal confirmation of spondylocostal dysostosis had a CRL well below the 5th percentile irrespective of the gestational age at which they were identified. This may serve as a diagnostic aid for this type of skeletal dysplasia that has normal long bones and a short trunk. By establishing a normogram for second-trimester CRL, the diagnosis of other conditions in which a shorter-than-expected fetal trunk is present may benefit from the application of this measurement. Application of these data to this and other early fetal growth disorders may also prove to be of utility as a diagnostic aid in the future.

### 2385788 A Novel Technique to Assess the Uterine Cervix: 3-Dimensional Sphere Application

Nicole Smith<sup>1</sup>, \* Caroline Rouse<sup>1</sup>, David Cantonwine<sup>1</sup>, Sarah Easter<sup>1</sup>, Thomas Shipp<sup>1</sup>

Obstetrics and Gynecology, Brigham and Women's Hospital, Boston, MA USA

**Objectives:** Three-dimensional assessment of cervical volume (CV) has shown early promise in risk stratification for preterm birth. However, little is known as to whether cervical volume changes over gestation or differs between multiparas and nulliparas. Additionally, no standardized technique exists for volume measurement. We developed a novel technique for CV measurement and aimed to describe CV in normal pregnancies across gestation.

**Methods:** CVs were collected prospectively on 276 women undergoing transvaginal TV ultrasound (US). CVs were measured using the virtual organ computer-aided analysis sphere application with the initial sphere volume set to 100 cm<sup>3</sup> ( $\pm 2$  cm<sup>3</sup>). The cervix and lower uterine segment were outlined in 6 (30°) planes. Volume was assessed at three gestational age (GA) ranges, 16+0–19+6 weeks, 20+0–23+6 weeks, and 24+0–27+6 weeks. Women with the US indication of cervical incompetence or preterm birth (PTB) were excluded. Twenty-five women in each group, all with singleton pregnancies resulting in term deliveries, were included. We examined differences in CV by GA at US both in the population overall and between nulliparas and multiparas and tested the differences by the Wilcoxon rank sum test. Spearman correlations were calculated between CV, cervical length (CL), and GA at US, stratified by parity status.

**Results:** CV and CL were moderately well correlated over gestation ( $r = 0.5$ ). Mean (SD) CVs in the 3 GA ranges were 59.0 (21.9), 64.4 (19.4), and 57.9 (13.8) cm<sup>3</sup>. CV differed by maternal parity (54.9 vs 63.6 cm<sup>3</sup>;

$P < .0001$ ). While CL was significantly correlated with gestational age ( $P = .004$ ), CV was not ( $P = .43$ ).

**Conclusions:** CV appears to remain stable over gestation, as opposed to CL, which is correlated with GA. CV may therefore be a useful adjunct to CL in assessing risk of PTB.

## Point-of-Care Ultrasound

Moderator: Arun Nagdev, MD

### 2384610 Computerized Detection of Abdominal Free Fluid in Focused Assessment With Sonography for Trauma Exams: A Pilot Study

Anna Sjogren<sup>1</sup>, \* Megan Leo<sup>1,2</sup>, Joseph Gwin<sup>3</sup>

<sup>1</sup>Emergency Department, Boston Medical Center, Boston, MA USA; <sup>2</sup>Emergency Department, Boston University School of Medicine, Boston, MA USA; <sup>3</sup>BioSensics LLC, Cambridge, MA USA

**Objectives:** The focused assessment with sonography for trauma (FAST) exam is an ultrasound exam used within emergency and critical care to detect free fluid in the setting of trauma. Interpretation of the FAST exam can be limited by operator experience. There may be a role for automated, computerized interpretation to assist those operators with minimal training. This pilot study tests the feasibility of automating the detection of free fluid in a FAST exam using image segmentation, feature selection, and machine learning.

**Methods:** Using an emergency ultrasound database, 10 positive and 10 negative right upper quadrant FAST exam videos from adult patients were randomly selected. Image segmentation identified hypoechoic regions of interest (ROI). Emergency physicians trained in ultrasound manually classified all hypoechoic ROIs as free fluid or not. Six geometric properties and eight grayscale color properties of the shapes and their surroundings were computed. These features were normalized and used as inputs to a radial basis function support vector machine (SVM) classifier. A 10-fold cross-validation assessed the sensitivity and specificity as compared to manual classification.

**Results:** On a shape-by-shape basis, the sensitivity and specificity of the SVM were 66.1% and 99.5%, respectively. On a frame-by-frame basis, the sensitivity and specificity were 74.9% and 98.6%, respectively. On a video-by-video basis, the sensitivity and specificity were 100% and 90%, respectively.

**Conclusions:** This pilot study demonstrates the feasibility of developing a computer program that would automate the detection of free fluid in the FAST exam. This technology could be expanded to all quadrants of the FAST exam. Much like the automated electrocardiogram read, this technology could assist providers in FAST interpretations and have a profound impact on patient care.

Table 1. SVM Classification Results

		Predicted	
		Positive	Negative
By Shape			
Actual	Positive	434	223
	Negative	9	1874
By Frame <sup>a</sup>			
Actual	Positive	286	96
	Negative	6	435
By Video <sup>b</sup>			
Actual	Positive	10	0
	Negative	1	9

<sup>a</sup>Frame is predicted positive if at least 1 shape in the frame is positive.

<sup>b</sup>Video is predicted positive if it has at least 1 sequence of  $\geq 2$  sequential positive frames.



**2384751 Sonographic Carotid Corrected Flow Time Measurement to Assess Hydration Status in Prolonged Fasting**  
**Hamid Shokoohi<sup>1</sup>, Grant Berry<sup>1,\*</sup>, Jordan King<sup>2</sup>, Jackson King<sup>1</sup>, Murteza Shakkolahi<sup>1</sup>, Ameneh Poshtmahad<sup>3</sup>, Mohammad Salimian<sup>1</sup>, Ali Pourmand<sup>1</sup>**

<sup>1</sup>Emergency Medicine, George Washington University, Washington, DC USA; <sup>2</sup>Pharmacotherapy, University of Utah, Salt Lake City, UT USA; <sup>3</sup>Radiology, Shady Grove Adventist Hospital, Rockville, MD USA

**Objectives:** Recent studies suggest that carotid corrected flow time (FTc) measured by bedside sonography can be used in assessing volume status and volume responsiveness. We aim to determine whether sonographic measurement of the carotid FTc in subjects with prolonged fasting is a reliable method to detect fluid status.

**Methods:** A prospective cohort of fasting people who presented at a community health fair at the Islamic Education Center during the month of Ramadan was recruited. All adult subjects who were fasting and had no preexisting cardiac diseases were eligible to participate. Sonographic carotid FTc measurements were obtained in the long-axis view while participants were fasting and repeated approximately 3 hours after breaking their fast. We measured FTc in both semi-Fowler's and passive leg-raising (PLR) positions. The primary outcome was to quantify changes in FTc from the fasting to the nonfasting states. Secondary outcomes included the correlation between changes in FTc associated with PLR in the fasting state and consuming fluids. FTc values were measured in real time and retrospectively by using a digital ruler, and the inter-rater reliability was calculated.

**Results:** In total, 123 participants with mean age of  $47 \pm 14$  years and 55% male were enrolled. Participants had fasted for an average of 16.9 hours and consumed an average of 933 mL between the 2 sonographic measurements. Significant increases in mean FTc were observed from the fasting to the nonfasting state ( $312 \pm 22$  vs  $345 \pm 25$  milliseconds;  $P < .001$ ). Relative changes in FTc from fasting to nonfasting states of  $>10\%$  and  $>5\%$  were observed in 68 (55.3%) and 92 (74.8%) participants, respectively. Multivariable mixed linear regression analyses, controlling for participant characteristics, demonstrated that the fasting state independently reduces FTc values (coefficient [95% confidence interval],  $-19.10 [-23.31 \text{ to } -4.88]$ ) and increases change in FTc from the PLR maneuver ( $6.08 [4.93 \text{ to } 7.24]$ ) relative to the nonfasting state.

**Conclusions:** The carotid FTc measured by using bedside sonography was significantly related to state of hydration among subjects with prolonged fasting. The FTc measurement can be used to accurately predict patients' fluid status.

**2385176 Risk Factors for Isolated Femoral and Deep Femoral Vein Thromboses**

**Jason Fields<sup>1</sup>, Shruti Chandra<sup>1,\*</sup>, Julie Gianakon<sup>2</sup>, Kunal Desai<sup>3</sup>, Arthur Au<sup>1</sup>**

<sup>1</sup>Emergency Medicine, Thomas Jefferson University, Philadelphia, PA USA; <sup>2</sup>Sidney Kimmel Medical College, Philadelphia, PA USA; <sup>3</sup>Rowan University, Stratford, NJ USA

**Objectives:** A dilemma of 2-point limited compression ultrasound is the potential to miss atypical deep vein thrombi (aDVTs) isolated to either the femoral or deep femoral veins. It is possible that aDVTs are associated with specific demographics or symptoms, but this has not been studied. The current study set out to identify clinical variables associated with the presence of aDVTs.

**Methods:** This was a retrospective study of 2 emergency departments with an annual census of 100,000. Patients who had radiology ultrasound and a diagnosis of DVT between 2011 and 2014 were included. Patients were excluded if the DVT was not an acute proximal DVT of the lower extremity. Chart review was performed by 2 trained research asso-

ciates, and demographic and clinical variables were extracted using a standardized data collection tool. Standard descriptive statistics were performed.

**Results:** A total of 748 patients were identified, with 464 patients having acute proximal DVTs for analysis. The mean age was 61 years (SD, 18) and 52% (239/464) were male. There were 23 cases (5.0%; 95 confidence interval, 3.2%–7.4%) of aDVTs (20 isolated femoral vein and 3 isolated deep femoral). The only variable found to be significantly associated with aDVT was pain localized to the thigh (Table 1).

**Conclusions:** Our study corroborates the findings of previous studies for a non-negligible (5%) incidence of aDVTs. Of patients with acute proximal DVTs, thigh pain is more commonly associated with aDVTs; however, whether this finding can be used to guide imaging strategies requires prospective evaluation.

Table 1. Clinical Variables Associated With Isolated Femoral or Deep Femoral DVTs

Variable	All Patients (n = 464)	Isolated Femoral or Deep Femoral DVTs (n = 23)	All Other Proximal DVTs (n = 441)	P
Elderly (age >65 y)	43% (197)	57% (13)	42% (184)	.16
Male gender	52% (239)	35% (8)	49% (217)	.18
Obesity	37% (173)	30% (7)	38% (166)	.49
History of DVT	36% (165)	48% (11)	35% (154)	.21
History of cancer	22% (103)	35% (8)	22% (95)	.14
Immobility	10% (44)	9% (2)	10% (42)	.90
Inguinal pain	4% (20)	9% (2)	4% (18)	.28
Thigh pain	10% (44)	22% (5)	9% (39)	.04
Knee pain	9% (41)	13% (3)	9% (38)	.47
Calf pain	14% (67)	9% (2)	15% (65)	.42

**2385209 How Does Clinical Ultrasound Affect the Patient-Physician Relationship?**

**Jason Fields<sup>1</sup>, Julie Gianakon<sup>1</sup>, Carl Alsop<sup>1,\*</sup>, Kunal Desai<sup>2</sup>, Arthur Au<sup>1</sup>**

<sup>1</sup>Emergency Medicine, Thomas Jefferson University, Philadelphia, PA USA; <sup>2</sup>Rowan University, Stratford, NJ USA

**Objectives:** Clinical ultrasound (cUS) has the potential to improve the patient-physician relationship through increased contact time and communication. The current study set out to determine if patients who receive cUS have a stronger connection with their providers.

**Methods:** This was a prospective matched case-control study performed in an urban academic emergency department (ED). Adult patients who had cUS were enrolled. Age- and gender-matched control patients who were seen by the same provider but who did not receive cUS were also enrolled. All patients were administered a survey of questions assessing the provider-patient relationship. Comparison between the 2 groups was performed using Student *t* and  $\chi^2$  tests.

**Results:** Seventy-two patients were enrolled (36 cases and 36 controls). The mean age was 50.4 years (SD, 18.3); 47% were male; and 53% were female. No significant difference was found between the 2 groups for any of the patient-provider relationship questions (Table 1). The cUS group had higher overall satisfaction, with 100% indicating they were "satisfied" or "very satisfied" with their ED visit, compared with 81% of the controls ( $P < .01$ ).

**Conclusions:** cUS did not appear to increase the provider-physician relationship using our adapted survey. cUS was associated with higher patient satisfaction.

Table 1. Patient-Provider Relationship Scores Between cUS and No-cUS Groups

Question	cUS Group	No-cUS Group
I find my ED team easily accessible	4.20	4.25
I feel content with my ED team's treatment	4.22	4.25
I feel comfortable talking to my ED team	4.53	4.44
My ED team and I agree on the nature of my symptoms	4.22	4.17
My ED team is dedicated to helping me	4.42	4.42
My ED team understands me	4.17	4.19
I trust my ED team	4.36	4.36
My EDR team has enough time for me	4.31	4.17
My ED team helps me	4.36	4.39

For each question, patients selected between “strongly agree,” “agree,” “neutral,” “disagree,” and “strongly disagree.” Survey adapted from the validated Patient-Doctor Relationship Questionnaire 9.

### 2385349 Corrected Flow Time: A Noninvasive Ultrasound Measure to Detect Preload Reduction by Nitroglycerin

**Joseph Pare,\* Rachel Liu, Christopher L. Moore, Basmah Safdar**

*Emergency Medicine, Yale University, New Haven, CT USA*

**Objectives:** Monitoring of patient's intravascular volume status without invasive measures remains challenging and unreliable. Our objective was to determine if corrected flow time (FTc) measurement could detect preload reduction with administration of nitroglycerin as a surrogate for volume loss.

**Methods:** FTc analysis was performed for a prospective cohort study of pulsed wave spectral Doppler measurements before and after administration of nitroglycerin. Patients enrolled were eligible for inclusion if they were admitted to a chest pain center for cardiac evaluation. Descriptive statistics, *t* tests, bivariate regression, and concordance correlations were performed as appropriate.

**Results:** Fifty-four patients had Doppler measurements available for review. Mean FTc decreased from 339 milliseconds (95% confidence interval [CI] 332–346) to 325 milliseconds (95% CI, 318–331) with administration of 0.3 mg of sublingual nitroglycerin ( $P < .001$ ). Mean heart rate increased 5 beats/min with administration of nitroglycerin ( $P < .0001$ ); however, there was no significant change in systolic or diastolic blood pressure.

**Conclusions:** FTc was able to detect a significant difference in preload reduction with 0.3 mg of nitroglycerin. FTc may be an early reliable noninvasive measure to detect changes in intravascular volume status.

### 2385428 Emergency Medicine Physician–Performed Transesophageal Echocardiography in Simulated Cardiac Arrest

**Donald Byars<sup>1</sup>,\* David Evans<sup>2</sup>, Turan Kayagil<sup>1</sup>, Matt Jones<sup>1</sup>, Michael Vitto<sup>2</sup>, Jordan Tozer<sup>2</sup>, Michael Joyce<sup>2</sup>**

*<sup>1</sup>Emergency Medicine, Eastern Virginia Medical School, Norfolk, VA USA; <sup>2</sup>Emergency Medicine, Virginia Commonwealth University, Richmond, VA USA*

**Objectives:** Transesophageal echocardiography (TEE) is an established method of evaluating cardiac pathology. It has many advantages over transthoracic echocardiography (TTE), including the ability to image the heart during active cardiopulmonary resuscitation. This is a prospective simulation study that aims to evaluate the ability of emergency medicine (EM) physicians to learn and apply TEE image acquisition techniques and demonstrate those techniques to identify common pathologic causes of cardiac arrest.

**Methods:** This was a prospective educational cohort study with 40 EM physicians from 2 participating academic medical centers who un-

derwent an educational module and a testing protocol. All participants were tested across 6 cases, including 2 normals, pericardial tamponade, acute myocardial infarction (MI), ventricular fibrillation (V-FIB), and 1 asystole presented in random order. Primary end points were correct identification of the cardiac pathology, if any, and time to sonographic diagnosis. Calculated end points includes sensitivity, specificity, positive predictive value, and negative predictive value for EM-performed TEE. A  $\kappa$  statistic was calculated to determine the degree of inter-rater reliability.

**Results:** Forty EM physicians completed both the educational module and testing protocol. This resulted in a total of 104 normal TEE studies and 208 pathologic TEE studies. Our calculations for the ability to diagnose life-threatening cardiac pathology by EM physicians in a high-fidelity TEE simulation resulted in sensitivity of 98.5%, specificity of 99%, a positive predictive value of 99.5%, and a negative predictive value of 97.1%. The average time to diagnose each objective structured clinical examination case was as follows: normal A in 35 seconds, normal B in 31 seconds, asystole in 13 seconds, tamponade in 14 seconds, acute MI in 22 seconds, and V-FIB in 12 seconds. Inter-rater reliability between EM physicians was extremely high, resulting in a  $\kappa$  coefficient across all cases of 0.95, where  $>0.9$  is considered to be “almost perfect.”

**Conclusions:** EM physicians can rapidly perform TEE studies in a simulated cardiac arrest environment with high degrees of precision and accuracy. Performance of TEE studies on human patients in cardiac arrest is the next logical step to determine if our simulation data hold true in clinical practice.

### 2385477 Three-Window Point-of-Care Ultrasound Confirmation of Correct Endotracheal Tube Placement

**Shadi Lahham<sup>1</sup>,\* Elizabeth Turner<sup>2</sup>, Sean Wilson<sup>1</sup>, Marc Rosen<sup>2</sup>, Arthur Youssefian<sup>1</sup>, Mohammed Subeh<sup>1</sup>, Craig Anderson<sup>1</sup>, J. Christian Fox<sup>1</sup>**

*<sup>1</sup>Emergency Medicine, University of California, Irvine, Orange, CA USA; <sup>2</sup>Intensive Care Unit, University of California, Irvine, Irvine, CA USA*

**Objectives:** Establishing a definite airway is often an initial step in the management of the critically ill patient. In the emergency setting, this can be particularly challenging, as previous studies have demonstrated that up to a quarter of emergent intubations result in the esophagus and another quarter that are initially placed in the trachea end in a main stem bronchus. We therefore sought to evaluate the accuracy of a comprehensive 3-window point-of-care ultrasound (POCUS) assessment to confirm correct endotracheal tube (ETT) placement.

**Methods:** This study was a prospective observational study using a convenience sample of patients who underwent emergent intubation between July 2011 and August 2013 in the emergency department or medical intensive care unit at a 422-bed level 1 trauma center with an annual emergency department census of 50,000 visits. After presumed successful ETT intubation, 3 sonographic windows were obtained, which included the trachea, bilateral lung sliding, and diaphragm movement. A 2-sample *t* test was used to compare the average time between ultrasound and plain-film radiography.

**Results:** A total of 140 patients were enrolled. There were no esophageal intubations. The 3-window POCUS method correctly identified 132 of 137 ETTs placed in the trachea with sensitivity and specificity of 96.4% (95% confidence interval [CI], 91.7%–98.8%) and 33.3% (95% CI, 0.8%–90.6%), respectively. Ultrasound assessment was completed on average 25 minutes quicker than usual confirmatory plain-film radiography (95% CI, 6.2–43.9 minutes;  $P = .005$ ).

**Conclusions:** The 3-window POCUS appears to be a quick and reliable method for the early confirmation of correct ETT placement in the trachea and not one of the main stem bronchi. With future advances in technology training, there may be a role to reduce the need for postintubation plain-film radiography. Additional large-scale studies are required to validate this conclusion.

# 2385846 Medical Student–Performed Point-of-Care Ultrasound: The Effect on Patient Satisfaction in the Emergency Department

Logan Villarreal<sup>1,\*</sup>, Deanna Lo<sup>1</sup>, Andrew Sumnicht<sup>1</sup>, Stephanie Gonda-Sanabria<sup>1</sup>, Daniel Udrea<sup>1</sup>, Richard Chyan<sup>1</sup>, Vi Am Dinh<sup>1,2</sup>

<sup>1</sup>Loma Linda University, Loma Linda, CA USA; <sup>2</sup>Emergency Medicine, Loma Linda University, Loma Linda, CA USA

**Objectives:** Although medical school ultrasound curriculum guidelines have not yet been standardized, some early-adopter programs have used student-performed point-of-care ultrasound (SP-POCUS) for educational purposes in the emergency department (ED) and elective rotations. This study set out to measure the effects that SP-POCUS might have on patient satisfaction in the ED.

**Methods:** Patient satisfaction surveys were collected from patients in an urban level I trauma ED at an academic institution. Patients were divided into 2 populations: a physician-indicated population in which SP-POCUS was potentially helpful to diagnosis and an educational population in which SP-POCUS was mainly for student learning. Indicated patients were randomized into control (completed survey prior to SP-POCUS) and experimental (completed survey after SP-POCUS) groups. Educational patients were matched to controls based on the length of stay and chief complaint. All patients completed a 5-question satisfaction survey based on a 5-point Likert scale. Experimental groups received an additional 5-question survey specific to SP-POCUS.

**Results:** A total of 481 patients with 200 indicated and 281 educational patients were enrolled. Average patient satisfaction for indicated SP-POCUS was 4.54 for the experimental group and 4.47 for the control group ( $P = .48$ ). Average patient satisfaction was 4.50 for patients receiving educational SP-POCUS and 4.43 for matched controls ( $P = .43$ ). Patients reported feeling comfortable during indicated SP-POCUS (4.51; confidence interval [CI], 4.36–4.67) and educational SP-POCUS (4.61; CI, 4.50–4.72) and would recommend ultrasound for a patient with a similar chief complaint (indicated: 4.38; CI, 4.21–4.56; educational: 4.52; CI, 4.39–4.64).

**Conclusions:** There were no significant positive or negative effects of SP-POCUS on patient satisfaction. Patients remained comfortable during the exam and recommended that SP-POCUS be performed on a patient with a similar chief complaint. These results suggest that SP-POCUS may be used as a tool for clinical ultrasound education while maintaining quality patient-centered care.

# 2382868 Lung Ultrasound for Evaluating Acute Chest Syndrome in Pediatric Patients With Sickle Cell Disease: So Easy Even a Medical Student Can Do It!

Stephanie Cohen<sup>1,2,3</sup>, \*Zayir Malik<sup>6</sup>, Robert Hagbom<sup>6</sup>, Adina Alazrak<sup>3</sup>, Courtney McCracken<sup>4</sup>, April Zmitrovich<sup>5</sup>, Claudia Morris<sup>2,7</sup>

<sup>1</sup>Emergency Medicine, <sup>2</sup>Pediatrics, <sup>3</sup>Radiology, <sup>4</sup>Pediatric Infectious Disease, Emory University School of Medicine, Atlanta, GA USA; <sup>5</sup>Emergency Medicine, Children's Healthcare of Atlanta, Atlanta, GA USA; <sup>6</sup>Emory University School of Medicine, Atlanta, GA USA; <sup>7</sup>Center for Cystic Fibrosis and Airway Disease Research, Emory University School of Medicine, Atlanta, GA USA

**Objectives:** We evaluated the feasibility of medical student–performed ultrasound (US) compared to chest x-ray (CXR) to identify patients with sickle cell disease (SCD) who have acute chest syndrome (ACS).

**Methods:** This is a prospective observational study that took place in 2 urban pediatric emergency departments. Children with SCD are repeatedly exposed to diagnostic radiation for the evaluation of ACS. Focused chest US can visualize lung consolidation and can be used to identify patients with ACS, thereby limiting radiation exposure in this pop-

ulation. Children with SCD were enrolled if they were receiving a CXR for evaluation of ACS. Medical students without experience in lung US underwent a focused training session conducted by a pediatric emergency physician with training in point-of-care ultrasound. The session consisted of a 1-hour didactic lecture followed by a 1-hour hands-on session. Focused lung US was performed by medical students and was interpreted as either positive or negative for lung consolidation. A blinded expert in point-of-care US reviewed studies for quality assurance and agreement. Sensitivity, specificity, and likelihood ratios (LRs) were calculated for test performance characteristics of ultrasound using CXR as a reference standard. Interobserver agreement ( $\kappa$ ) between enrolling sonologists and the reviewer was also calculated.

**Results:** Three medical students completed the training and enrolled 85 patients, for a total of 98 cases. Median age was 7 years (interquartile range, 2–13 years), and 53% of patients were male. The prevalence of ACS by CXR was 14%. Lung US was able to detect consolidation with sensitivity of 86% (95% confidence interval [CI], 56%–97%), specificity of 95% (95% CI, 87%–98%), a positive LR of 18 (95% CI, 7–48), and a negative LR 0.2 (95% CI, 0.04–0.5). The agreement between enrolling novice sonologists' interpretation and the blinded reviewer's interpretation was very good, with a Cohen  $\kappa$  of 0.86 (95% CI, 0.7–1).

**Conclusions:** With limited training, novice medical student sonologists were able to identify ACS with high specificity. There was very good agreement between novice and expert sonologist interpretation.

# 2385154 Does Carotid Intima-Media Thickening Predict a Negative Stress Test in Low-Risk Chest Pain?

Matthew Tabbat

Emergency Department, MetroHealth Medical Center, Cleveland, OH USA; Case Western Reserve University School of Medicine, Cleveland, OH USA

**Objectives:** Chest pain is a common presentation to the emergency department (ED). Patients frequently undergo stress testing following negative diagnostic markers. Carotid intima-media thickness (CIMT) is a useful tool to noninvasively identify patients with a higher atherosclerotic burden. CIMT has been shown to be associated with myocardial infarction, stroke, coronary artery disease (CAD), as well as angiographic evidence of CAD. There are no known studies evaluating the use of CIMT on low-risk chest pain patients in an ED observation (OU) setting. The goal of this study is to evaluate CIMT in the ED OU to determine if it can be used as a tool to help predict patients who will have a negative stress test in attempt to risk stratify patients complaining of chest pain.

**Methods:** This is an ongoing prospective convenience sample of patients admitted to our ED OU with chest pain, dyspnea, or symptoms determined to be a coronary equivalent by the treating physician in the ED. Patients were included if they were to receive a stress test during their observation stay or had received one within 2 months prior to the ED OU visit. Patients were scanned with a high-frequency linear transducer in the long axis to the carotid artery. Three measurements of the IMT were taken on each side proximal to the carotid bulb within 1 cm of the bulb. The results were averaged on each side. The results were compared to a known standard for age and ethnicity at the 75th percentile. IMT above the 75th percentile for age and ethnicity on either side was considered a positive result.

**Results:** To date, 59 patients were evaluated. Five had a positive stress test (8.8%; 0.95 confidence interval [CI], 1.4%–16.2%). Of the 57 patients, 37 patients (64.9%; 0.95 CI, 52.5%–77.3%) had a negative IMT study, and 20 (35.1.2%; 0.95 CI, 22.7%–47.5%) had a positive IMT study. There were 4 patients among the positive stress group who had a positive IMT (80%; 0.95 CI, 44.9%–100%) and 1 patient with a negative IMT (20%; 0.95 CI, 0%–55.1%).

**Conclusions:** In this cohort of patients with low-risk chest pain was a trend toward negative stress correlating with negative IMT. However, data are insufficient to confidently risk stratify patients based on IMT alone.



## Ultrasound in Medical Education

*Moderators: David Bahner, MD, RDMS,  
Charlotte Henningsen, MS, RT, RDMS, RVT*

### 2349408 Multidisciplinary Ultrasound Leadership Training Initiative: Comprehensive Evaluation of a Novel Near-Peer Medical Student Ultrasound Training Program

*Daniel Francescon,\* David Way, Tyler Dschaak, David Bahner  
The Ohio State University College of Medicine, Columbus, OH  
USA*

**Objectives:** This study aims to evaluate the efficacy of a novel near-peer teaching program as a model for medical students to learn ultrasound.

**Methods:** Third-year (M3) medical school students begin by training a small group of interested M2 students in a set of specialty-specific scans. Each M3 student will then use the trained M2 students to serve as proctors and models during a didactic and clinical training session for novice ultrasound learners (mostly M1s). All novice participants completed preinstruction and postinstruction knowledge tests, self-ratings of ultrasound skills, and a satisfaction survey. Peer-instructors completed a preinstruction and postinstruction practical examination as well as a preinstruction and postinstruction self assessment of their own ultrasound skill and teaching ability. M3 students were assessed using comprehensive knowledge exams and surveys.

**Results:** Those who participated as proctors showed an increase in basic ultrasound knowledge and skills and also self-reported an increase in comfort with various ultrasound-related tasks as well as in comfort with teaching skills. Those who participated as novice learners also showed a statistically significant improvement in ultrasound knowledge while self-reporting an increase in comfort with various ultrasound-related tasks. Novice learners also rated the multidisciplinary ultrasound leadership training initiative (MULTI) sessions highly on a follow-up program evaluation. Data from M3 leaders is under analysis currently.

**Conclusions:** Initial results of the MULTI program demonstrate the efficacy of using a near-peer teaching model for expanding ultrasound education in medical school. The MULTI program helped both learners and peer-instructors to see the practical application of ultrasound across a spectrum of specialties, particularly ones in which participants were interested. The MULTI program not only taught new ultrasound skills but also helped reinforce foundational skills and knowledge. Peer-instructors and leaders developed teaching skills in ultrasound acquisition and interpretation.

### 2383966 Does an Integrated Undergraduate Medical Ultrasound Program Enhance Medical Student Recruitment?

*Felicia Toreno, Craig Goodmurphy,\* Barry Knapp, Donald Byars, Frank Lattanzio  
Eastern Virginia Medical School, Norfolk, VA USA*

**Objectives:** Eastern Virginia Medical School (EVMS) implemented a blended-learning, simulation-enhanced ultrasound curriculum for medical students during the 2012–2013 academic year. Our goal was to assess whether the presence of an integrated ultrasound curriculum contributed to a student's decision to attend our medical school.

**Methods:** A questionnaire was administered to new EVMS medical students during the introductory week of their first year of medical school. Students were asked if the inclusion of an integrated ultrasound curriculum was a reason they chose to attend EVMS.

**Results:** A total of 144 incoming first-year medical school students were surveyed. Twenty-five percent of students (n = 36) identified the undergraduate ultrasound curriculum as a reason they chose to attend EVMS.

**Conclusions:** The presence of an integrated undergraduate ultrasound curriculum has the capacity to enhance medical student recruitment.

### 2384041 Medical Student Perceived Value of Ultrasound Education During the First Year of Medical School

*Felicia Toreno, Craig Goodmurphy,\* Barry Knapp, Donald Byars, Frank Lattanzio  
Eastern Virginia Medical School, Norfolk, VA USA*

**Objectives:** To assess student perception of the value of ultrasound education during the first year of medical school.

**Methods:** An electronic survey was administered to learners on the completion of their first year of undergraduate medical ultrasound curriculum. Year 1 students in 2 academic years were surveyed.

**Results:** Two hundred thirty-six students (95%) felt that the overall educational experience in ultrasound enhanced their undergraduate medical education (n = 247). Two hundred forty-eight (93%) reported that they would like to see more ultrasound included in the undergraduate medical curriculum (n = 266).

**Conclusions:** A large majority of first-year medical students believed that the integration of ultrasound into their curricula enhanced their undergraduate medical education. Most students desire more ultrasound within the curricula.

### 2384071 Pair Scanning: Integrating the Student Sonographer Without Impacting Patient Care

*Marcia Docherty,\* Kathleen Foran, Susan Burnett-Roy  
Diagnostic Medical Sonography, Canadian National Institute of Health, Ottawa, Ontario, Canada*

**Objectives:** During an ultrasound placement, the student sonographer is often provided time to examine patients before or after they have been examined by a registered sonographer. This practice, which increases patient examination times for student training, is limiting access to clinical training placements not only because it reduces patient volumes but also negatively affects revenue. Moreover, this practice requires patients to undergo 2 ultrasound examinations. A research project was launched to challenge this practice by developing a pair-scanning protocol that can integrate the student sonographer into the workplace without impacting patient care and tested whether the protocol prepares the student sonographer for entry-level practice faster than traditional practice.

**Methods:** This research project was conducted in 2 phases. The first phase used action research to design and develop a pair-scanning protocol. The second phase examined the transferability of the protocol using mixed methods.

**Results:** Phase 1 produced a pair-scanning protocol that effectively integrated the student sonographer into a busy clinic without impacting patient care and prepared her for entry-level practice faster than traditional practice. The student logged more total examinations and logged statistically significantly more independent exams than her cohort ( $H = 36.297$ ;  $P < .01$ ). The phase 2 results demonstrated that students can be integrated into a variety of sites without a reduction in patient volumes. The pair-scanning group (n = 5) and the control group (n = 9) performed equally.

**Conclusions:** Student sonographers can be integrated into the work flow without impacting patient care. The pair-scanning protocol provides a framework for this integration and may be most effective for weak to average students.

### 2384600 Midwifery Students' Perceptions of the Importance of Ultrasound in Medical Education in Lebanon

Reem Abu-Rustum<sup>1,2</sup>,\* M. Fouad Ziade<sup>3</sup>

<sup>1</sup>Center for Advanced Fetal Care, Tripoli, Lebanon; <sup>2</sup>SANA Medical NGO, Tripoli, Lebanon; <sup>3</sup>Faculty of Public Health, Lebanese University, Tripoli, Lebanon

**Objectives:** Evaluate 4th-year midwifery students' perceptions of the importance of ultrasound (US) before and after the first integrated US course in the midwifery curriculum in Lebanon.

**Methods:** Responses to precourse and postcourse surveys from 14 enrolled students were collected. Using a 5-level Likert scale, students responded to questions in 5 categories: exposure to US and need of training; role of US in enhancing comprehension of obstetrics (OB) and gynecology (Gyn); importance of US integration into medical education; role of US in their future; and postcourse impressions. Data were analyzed using the Mann-Whitney nonparametric test.  $P < .05$  was considered significant.

**Results:** All students completed precourse and postcourse surveys with an individual response rate  $>95\%$  to each question. Even though 78% of students agreed/strongly agreed (A/SA) to sufficient exposure to US after the course in comparison to 42.9% before the course ( $P = .05$ ),  $>85\%$ , both before and after the course, indicated their persisting need for more structured instruction in US. Persisting before and after the course,  $>95\%$  of students A/SA on the role of US in enhancing their Ob knowledge. On the other hand, their perception toward the role in Gyn declined significantly from  $\approx 75\%$  to 40% ( $P = .021$ ). Students' perceptions were as strong before and after the course on the role of US in medical education and their future clinical practice:  $>85\%$  of students A/SA to the importance of US integration into their own education and globally, and  $>95\%$  of students A/SA to the role of US in their future clinical practice. After the course, all students SA to the course benefits and their willingness to serve as future instructors.

**Conclusions:** Our study demonstrates that US integration into medical education is a positive experience for midwifery students, enhancing their knowledge. Our data indicate the insufficiency of our course in addressing their Gyn needs and the need for earlier and longer structured training in Ob sonography. The student's strong belief in US's clinical applicability in their future, the need for its universal implementation, together with their willingness to serve as future instructors, provide further evidence in support of the importance of global implementation of US in medical education.

### 2385125 Comparison of Third-Year Medical Students Using Vscan Handheld Ultrasound With Obstetric Sonographers for Determination of Biparietal Diameter and Fetal Lie in Obstetric Patients

Felicia Toreno, Barry Knapp, Craig Goodmurphy, Donald Byars, Khaled Sakhel\*

Eastern Virginia Medical School, Norfolk, VA USA

**Objectives:** The purpose of this study was to evaluate the accuracy of third-year medical students (M3) in measuring fetal biparietal diameter (BPD) and determination of fetal lie (FL) using handheld ultrasound as compared to experienced sonographers using hospital-based ultrasound systems.

**Methods:** This was a prospective observational study evaluating M3 students' accuracy in measuring BPD and determining FL during the second and third trimesters of pregnancy. M3 students utilized a GE Vscan handheld ultrasound machine during their obstetrics and gynecology clerkship at Eastern Virginia Medical School. During the clerkship, students were required to measure BPD and determine FL on patients determined to need a formal ultrasound exam. Students were asked to perform the ultrasound first unaided, followed by a second-trimester scan by sonographers. Student Vscan assessments were compared with those of 14 experienced American Registry for Diagnostic Medical Sonography-

certified obstetric sonographers using traditional ultrasound systems. The 2-tailed Student  $t$  test was used to assess statistical significance between the 2 groups via  $P$  values and to determine 95% confidence intervals (CIs). For the determination of fetal lie, a  $\kappa$  coefficient statistic was used to determine the level of agreement between sonographers. An a priori estimation of sample size for statistical power was performed utilizing Cohen's delta.

**Results:** BPD measurements were recorded by 128 students, while 130 students obtained FL (M3 total class size = 155). No statistical difference was noted between the BPD measurements obtained by students versus experienced sonographers ( $P = .58$  with difference between the means of  $-0.11$  with a 95% CI from  $-0.54$  to  $0.30$ ). The  $\kappa$  coefficient for inter-rater reliability for assessment of fetal lie was 1.0, resulting in a strong level of agreement between the M3 and obstetric sonographers. The a priori sample size calculation of 128 was met for both measured end points.

**Conclusions:** Results indicate that M3 students can accurately determine BPD and fetal lie using the Vscan handheld ultrasound machine as compared to experienced sonographers using traditional ultrasound machines.

### 2385197 Collaboration Between Eastern Virginia Medical School (EVMS) and the Diagnostic Medical Sonography Program at Tidewater Community College in the Implementation of Ultrasound Into the Medical School Curriculum at EVMS

Felicia Toreno<sup>1</sup>,\* Barry Knapp<sup>1</sup>, Craig Goodmurphy<sup>1</sup>, Donald Byars<sup>1</sup>, Frank Lattanzio<sup>1</sup>, Indu Sharma<sup>2</sup>

<sup>1</sup>Eastern Virginia Medical School, Norfolk, VA USA; <sup>2</sup>Diagnostic Medical Sonography, Tidewater Community College, Virginia Beach, VA USA

**Objectives:** As Eastern Virginia Medical School (EVMS) made the decision to implement an ultrasound component into the existing medical education curriculum, it looked for support and input from a local source of sonography education: Tidewater Community College (TCC). With a well-established and accredited diagnostic medical sonography (DMS) program, TCC was able to offer supporting equipment as well as manpower. This collaboration has proven to be successful for both partners and has highlighted the strengths of both partners. We hope to encourage other such collaborations to be developed.

**Methods:** EVMS and TCC have collaborated to utilize resources provided by sonographers in scanning labs built into the medical student ultrasound learning labs. The community college provides faculty, students, and equipment to help run scanning labs for first- and second-year medical school students. DMS faculty earn community respect; DMS students gain self-confidence and EVMS gains additional qualified faculty and mentoring staff. In addition, the medical students learn to respect the skills and capabilities of sonographers.

**Results:** EVMS and TCC have established what we feel is a benchmark collaboration between a community college and a medical school. All parties recognize the strengths of the other and gain something from the collaborative effort, including the most important of all: the medical students themselves.

**Conclusions:** When medical schools make curriculum changes, resources are often limited. One very effective resource available to medical schools may already be available within the community: the local community college-based sonography program. In the model of collaboration between EVMS and TCC, both partners benefit from the current collaborative process, and both partners would be negatively impacted without this partnership. As educators embrace the concepts of learning across curricula and interdepartmental learning, this medical-based skill set provides a good means to do just that at both educational levels. Further studies are underway at EVMS to see if the interactions with sonographers change general perceptions of medical students regarding sonographers as health care workers.

**2385233 Does the Addition of an Integrated Cardiac Ultrasound Curriculum to the M1 and M2 Years of Medical Education Enhance Comprehension of Cardiac Physiology and Pharmacology?**

*Felicia Toreno, Frank Lattanzio,\* Craig Goodmurphy, Barry Knapp, Donald Byars*

*Eastern Virginia Medical School, Norfolk, VA USA*

**Objectives:** Cardiac physiology is an educational challenge to entering medical students. Deficiencies in learning manifest in lower cardiac physiology test grades and lower student course evaluation scores. These deficits may carry over into the second-year (M2) medical school student's performance in cardiovascular pharmacology and may impact clinical years. Our hypothesis is that by using ultrasound (US) to visualize the cardiac cycle, medical students can better comprehend and retain elements of cardiac mechanics and function.

**Methods:** The average grade point average (GPA) and Medical College Admission Test (MCAT) scores of entering classes at Eastern Virginia Medical School (EVMS) were used to estimate performance of first-year medical students who were taught cardiac physiology by EVMS faculty. Standardized test questions were used to create 2 examinations on cardiac physiology. Student course evaluation results were collected using a Likert scale. The most recent student groups also received US training. US training included didactic and "hands-on" laboratory sessions scanning standardized patients.

**Results:** The average GPAs and MCAT scores of years 2003–2011 medical students were not significantly different from years 2012 and 2013. In 2003–2011, the averaged scores for both cardiac physiology exams were  $81.5 \pm 2.8$ . In 2012 and 2013, the averaged scores were 88.35 and 86.5, respectively, significantly higher than the 2003–2011 average, while other physiology tests scores were not significantly different. Physiology course evaluations averaged  $3.92 \pm 0.89$ , higher than  $3.21 \pm 0.63$  in the previous years. Student surveys showed that  $\approx 99\%$  affirmed that learning US improved their overall medical school experience. The class data demonstrated positive trends linking cardiovascular pharmacology/physiology scores with US scanning.

**Conclusions:** Our data show upward trends in cardiovascular physiology and pharmacology test scores, student course evaluations, and overall medical school experience when US is integrated into the medical school curriculum. We will continue to follow the performance of medical student classes to determine if there will also be a trend for improvement in clinical tasks involving elements of cardiac physiology in the third and fourth years of medical school.



## SCIENTIFIC SESSIONS

SUNDAY, MARCH 20, 2016, 4:00 PM–5:30 PM

## Elastography

Moderator: Shigao Chen, PhD

**2385532 Shear Wave Elastography for Liver Fibrosis Staging: Validating Cutoff Values for  $\geq$ F2 Fibrosis**Manish Dhyani<sup>1</sup>, \* Joseph Grajo<sup>3</sup>, Changtian Li<sup>1</sup>, Atul Bhan<sup>2</sup>, Raymond Chung<sup>4</sup>, Anthony Samir<sup>1</sup><sup>1</sup>Abdominal and Interventional Radiology, <sup>2</sup>Radiology, Massachusetts General Hospital, Boston, MA USA; <sup>3</sup>Radiology, University of Florida, Gainesville, FL USA; <sup>4</sup>Massachusetts General Hospital, Boston, MA USA**Objectives:** To determine the validity of previously established estimated liver Young's modulus (eYM) cutoff values for  $\geq$ F2 fibrosis in a cohort of patients with chronic liver diseases.**Methods:** In this Institutional Review Board–approved Health Insurance Portability and Accountability Act–compliant prospective study, a total of 338 patients undergoing liver biopsy from January 2014 to January 2015 underwent shear wave elastography (SWE) using an Aixplorer ultrasound machine (SuperSonic Imagine, France). Sets of 10 elastograms were obtained in the right upper lobe utilizing an intercostal approach at the end of normal expiration. Median SWE values were calculated. Sixty-one patients were excluded (allografts = 29, low-quality SWE = 25). A single blinded subspecialty-trained pathologist performed METAVIR fibrosis staging on all biopsy samples. Receiver operating characteristic (ROC) curves were computed for distinguishing higher grades ( $\geq$ F2) of liver fibrosis from F0 and F1 fibrosis.**Results:** A total of 277 subjects (male:female = 125:152) with a mean age of 48 years were analyzed. The reason for biopsy was liver disease workup in 55.6% of patients (n = 154) and follow-up of known liver disease in 44.4% (n = 123). On pathologic examination, a total of 212 subjects had either no fibrosis (F0; n = 108 [39.0%]) or F1 fibrosis (n = 104 [37.5%]), while 28 had F2 fibrosis (10.1%), 27 had F3 fibrosis (9.7%), and 10 had F4 fibrosis (3.6%). Spearman's correlation showed moderate correlation of fibrosis with eYM ( $r = 0.456$ ;  $P < .001$ ). A cutoff value of 7.29 kPa yielded sensitivity and specificity of 95% and 51%, respectively, test performance results similar to those defined in our prior work.**Conclusions:** A cutoff value of 7.29 kPa has been validated to have sensitivity of  $\approx$ 95% and specificity of  $\approx$ 50% for the diagnosis of METAVIR stage  $\geq$ F2 fibrosis.

Table 1

	Initial Cohort (Samir, Radiology 2015)	Validation Cohort
n	136	277
Mean age (range)	49 y (18–74 y)	48 y (18–82 y)
Cutoff value for METAVIR $\geq$ F2 fibrosis	7.29 kPa	7.29 kPa
Area under the ROC curve	0.77 (0.68–0.86)	0.84 (0.78–0.89)
Sensitivity	91.4% (95% CI, 75.6%–97.8%)	95.4% (95% CI, 86.2%–98.8%)
Specificity	52.5% (95% CI, 42.3%–62.4%)	50.5% (95% CI, 43.6%–57.4%)
Positive predictive value	40.0% (95% CI, 29.4%–51.6%)	37.1% (95% CI, 29.9%–44.97%)
Negative predictive value	94.6% (95% CI, 84.2%–98.6%)	97.3% (95% CI, 91.65%–99.29%)

CI indicates confidence interval.

**2376985 Performance of 2-Dimensional Ultrasound Shear Wave Elastography in Liver Fibrosis Detection Using Magnetic Resonance Elastography as the Reference Standard: A Pilot Study**Pengfei Song<sup>1</sup>, \* Daniel Mellema<sup>1</sup>, Shannon Sheedy<sup>2</sup>, Duane Meixner<sup>2</sup>, Ryan Karshen<sup>2</sup>, Matthew Urban<sup>1</sup>, Armando Manduca<sup>1</sup>, William Sanchez<sup>3</sup>, Matthew Callstrom<sup>2</sup>, James Greenleaf<sup>1</sup>, Shigao Chen<sup>1</sup><sup>1</sup>Physiology and Biomedical Engineering, <sup>2</sup>Radiology, <sup>3</sup>Gastroenterology, Mayo Clinic College of Medicine, Rochester, MN USA**Objectives:** To investigate the correlation between 2D ultrasound shear wave elastography (SWE) and magnetic resonance elastography (MRE) in liver stiffness measurement and the diagnostic performance of 2D SWE for liver fibrosis detection when imaging from different intercostal spaces and using MRE as the reference standard.**Methods:** Two-dimensional SWE was performed on 47 patients (22 females, 25 males, age 19–77 years) using the GE LOGIQ E9 (LE9) scanner. LE9 uses the comb-push ultrasound shear elastographic technique to simultaneously produce multiple shear waves inside the tissue to improve shear wave imaging quality. Each of the 47 patients had same-day MRE obtained for clinical purposes. Two-dimensional SWE measurements were acquired from the 9th, 8th, and 7th intercostal spaces. Correlation with MRE was calculated at each intercostal space and multiple intercostal spaces combined. The performance of 2D SWE in diagnosing liver fibrosis was evaluated with receiver operating characteristic (ROC) curve analysis using MRE as the standard.**Results:** The overall success rate of SWE measurements was 93% using LE9 2D SWE. The highest correlation between 2D SWE and MRE was from the 8th and 7th intercostal spaces ( $r = 0.68$ – $0.76$ ). The ranges of the areas under the ROC curve for separating normal or inflamed livers from fibrotic livers using MRE as the clinical reference were 0.84–0.92 when using the 8th and 7th intercostal spaces individually and 0.89–0.9 when combined, with 0.76–0.89 sensitivity and 0.83–0.96 specificity. High inter- and intra-rater correlation coefficients were obtained for the LE9 2D SWE: 0.995 and 0.987, respectively.**Conclusions:** The results suggest that 2D SWE and MRE are well correlated when SWE is performed at the 8th and 7th intercostal spaces. The 9th intercostal space is less reliable for diagnosing fibrosis using 2D SWE. Combining measurements from multiple intercostal spaces does not significantly improve 2D SWE performance for fibrosis detection. This study suggests that repeated liver stiffness measurements from a single intercostal space that provides the best acoustic window may be sufficient for diagnosing liver fibrosis using 2D SWE.**2379753 Pediatric Cardiac Shear Wave Elastography: A Pilot Study on Healthy Controls**Pengfei Song<sup>1</sup>, \* Xiaojun Bi<sup>2,3</sup>, Daniel Mellema<sup>1</sup>, Armando Manduca<sup>1</sup>, Matthew Urban<sup>1</sup>, Patricia Pellikka<sup>2</sup>, Shigao Chen<sup>1</sup>, James Greenleaf<sup>1</sup><sup>1</sup>Physiology and Biomedical Engineering, <sup>2</sup>Medicine, Division of Cardiovascular Diseases, Mayo Clinic College of Medicine, Rochester, MN USA; <sup>3</sup>Ultrasound, Tongji Medical College, Tongji Hospital, Huazhong University of Science and Technology, Wuhan, Hubei, China**Objectives:** The long-term goal of this study is to assess chemo-induced cardiotoxicity for pediatric cancer patients using cardiac ultrasound shear wave elastography (cSWE). This pilot study aimed to systematically investigate the feasibility of using cSWE in children and provide myocardial stiffness control data for the cancer patients.**Methods:** Twenty healthy volunteers (ages 5–18 years) were recruited and scanned 3 times on 3 different days. A novel cSWE sequence with pulse inversion harmonic imaging and time-aligned sequential track-

ing was developed for this study. cSWE was implemented using an adult and a pediatric cardiac transducer (P4-2 and P7-4; Philips Healthcare), driven by a Verasonics ultrasound system. The Verasonics was electrocardiographically gated to produce and detect a transient shear wave propagating in the myocardium in late-diastole. Two-dimensional shear wave speed (SWS) maps of the myocardium were reconstructed for data analysis.

**Results:** The parasternal long-axis (L-A) and short-axis (S-A) views of the interventricular septum (IVS) were found to be feasible for reliable shear wave measurement. The inter- and intra-rater correlation coefficients for SWS measurements were 0.86 and 0.77, respectively. The L-A and S-A views of the basal and mid IVS provided better success rates than those of the apical IVS. Success rate decreased with increased body mass index but did not differ with age or gender. SWS measurements were 1.26, 1.22, 1.71, and 1.67 m/s for L-A base, L-A mid, S-A base, and S-A mid IVS, respectively. All S-A SWS values were significantly higher ( $P < .01$ ) than L-A values due to myocardial anisotropy, corroborating a prior animal study and MRI tractography results. No SWS difference was observed for different ages and genders. Among successful SWS measurements, 90% were found to be repeatable across different days.

**Conclusions:** This pilot study demonstrated, for the first time, the feasibility of using cSWE to measure quantitative myocardial stiffness in children and established control SWS values for using cSWE to assess chemo-induced cardiotoxicity for pediatric cancer patients. The results showed that the myocardial anisotropy needs to be accounted for when comparing SWS from different scan views. No SWS difference was observed for age or gender.

#### 2369615 Correlation of Cognitive Function With Strain Indices for Accessing Carotid Plaque Instability

*Nirvedh Meshram<sup>1,\*</sup>, Xiao Wang<sup>6</sup>, Daren Jackson<sup>2</sup>, Carol Mitchell<sup>3</sup>, Tomy Varghese<sup>4</sup>, Stephanie Wilbrand<sup>5</sup>, Bruce Hermann<sup>2</sup>, Robert Dempsey<sup>5</sup>*

<sup>1</sup>Electrical and Computer Engineering, <sup>2</sup>Neurology, <sup>3</sup>Cardiovascular Medicine, <sup>4</sup>Medical Physics, <sup>5</sup>Neurosurgery, University of Wisconsin, Madison, WI USA; <sup>6</sup>Radiation Oncology, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ USA

**Objectives:** Carotid plaque vulnerable to rupture can generate cerebral microemboli in the microvasculature, which may cause subsequent cognitive impairment. Vulnerable plaques may be identified with ultrasound-based carotid strain imaging. Localized regions of interest (ROIs) with maximum strain tensor values (strain indices) are identified by assessing the strain distribution spatially and temporally across a cardiac cycle. We examined the relationship between maximum strain indices and cognition before carotid endarterectomy.

**Methods:** Presurgical strain imaging and cognitive evaluations were obtained from 51 patients (31 symptomatic for stroke/transient ischemic attack; 20 asymptomatic). ROIs surrounding the maximum value of accumulated strain were identified around the center of the ROI. Maximum strain in each frame was obtained by averaging the strain values in each ROI, and temporal progression of the mean strain within this ROI was studied. Cognition was tested using the 60-minute test battery of National Institute of Neurological Disorders and Stroke–Canadian Stroke Network Vascular Cognitive Impairment Harmonization Standards and assessed language, memory, visuospatial, motor, and executive function.

**Results:** In patients symptomatic for stroke, strain values were positively correlated with time taken to reproduce a complex figure ( $r = 0.616$ ;  $P < .001$ ) and inversely correlated with memory for that figure ( $r = -0.441$ ;  $P < .012$ ), while asymptomatic patients demonstrated an inverse correlation between maximum strain and executive function ( $r = -0.590$ ;  $P = .006$ ). Both groups showed a relation between strain and a coding (symbol substitution) task ( $r = -0.522$ ,  $-0.752$ ;  $P = .002$ ,  $.001$ ).

**Conclusions:** Maximum strain indices in carotid plaque can serve as vascular biomarkers associated with specific cognitive deficits depending in part on symptomatic status. Although the etiology of these impairments is still uncertain, our results suggest that the decline of motor function, speeded motor function, executive function, visual attention, and visuospatial learning may be associated with embolization related to high strain indices in carotid plaque. (Funded in part by National Institutes of Health grants R21 EB010098, R01 NS064034, and 2R01 CA112192.)

#### 2381340 Strain-Based Vascular Biomarkers for Classification of Patients With Cognitive Impairment

*Xiao Wang<sup>1</sup>, Daren Jackson<sup>2</sup>, Carol Mitchell<sup>3</sup>, Tomy Varghese<sup>4,\*</sup>, Stephanie Wilbrand<sup>4</sup>, Brandon Rocque<sup>4</sup>, Bruce Hermann<sup>2</sup>, Robert Dempsey<sup>4</sup>*

<sup>1</sup>Medical Physics, <sup>2</sup>Neurology, <sup>3</sup>Section of Cardiovascular Medicine, <sup>4</sup>Neurological Surgery, University of Wisconsin, Madison, WI USA

**Objectives:** Cognitive impairment has different etiologies, with microemboli from carotid plaque being one of the causative factors. We have previously reported on maximum strain indices in the carotid wall and plaque as vascular biomarkers demonstrating strong correlations with cognitive function. Here we evaluate the ability of these biomarkers to differentiate between low- and high-cognition patient groups.

**Methods:** Ultrasound-based carotid strain imaging and cognition assessment were performed on 75 patients. Ultrasound radiofrequency data for strain imaging were acquired, along with clinical B-mode and color flow Doppler images, on patients using either a Siemens Antares or S2000 ultrasound system (Siemens Ultrasound, Mountain View, CA) equipped with a VFX 13-5 or 18L 6 linear array transducer. A standardized cognitive test battery, using either the Repeatable Battery for the Assessment of Neuropsychological Status or the National Institute of Neurological Disorder and Stroke–Canadian Stroke Network Vascular Cognitive Impairment Harmonization Standard, was administered. Cognition scores were standardized within each of these tests to combine and compare to strain indices as  $z$  scores.

**Results:** A negative association between cognitive  $z$  scores and maximum strain indices was observed. Patients with higher strain indices performed poorly on cognitive assessment tests and vice versa. Strain indices utilized to differentiate between the lower- and higher-cognition groups provided area under the curve (AUC) values between 0.75 and 0.8 for all patients, improving to between 0.78 and 0.85 for symptomatic patients. Lateral strain indices exhibited the best performance, with an AUC of 0.79 for all patients and 0.85 for symptomatic patients.

**Conclusions:** All correlations were significant at  $P < .05$ , and our vascular strain indices demonstrate good classification performance for cognitive impairment. This study supports our hypothesis that microemboli resulting from the rupture of vulnerable plaque, manifesting as local regions with increased strain or deformation, may lead to cognitive impairment. (This work was supported in part by National Institutes of Health grants R21 EB010098, R01 NS064034, and 2R01 CA112192.)

#### 2383351 Effect of Various Technical and Patient-Related Factors on the Success Rate of Acoustic Radiation Force Impulse Elastography in Patients With Morbid Obesity

*Anil Chauhan<sup>1,\*</sup>, Chandra Sehgal<sup>1</sup>, Kristoffel Dumon<sup>2</sup>, Noel Williams<sup>2</sup>, Andy Milkowski<sup>3</sup>, Christopher Neylan<sup>1</sup>*

<sup>1</sup>Radiology, <sup>2</sup>Surgery, University of Pennsylvania, Philadelphia, PA USA; <sup>3</sup>Siemens Medical Inc, Issaquah, WA USA

**Objectives:** Liver stiffness with transient elastography can have a failure rate of up to 59% in obese patients, which is an important segment of the American population. The objective of this study was to evaluate the effect of technical and patient-related factors on the success rate of acoustic radiation force impulse (ARFI) shear wave speed (SWS) in morbidly obese patients undergoing bariatric surgery.

**Methods:** ARFI shear wave speed measurements were made in 34 patients prospectively, using 6C1 (34 patients) and 4V1 (10 patients) probes. An unreliable ARFI exam was defined as interquartile range/median (IQR/M) stiffness  $>0.3$ . Two groups with skin-to-liver thickness (SLT)  $<3$  or  $\geq 3$  cm were assessed. Body mass index (BMI), steatosis, age, and gender were additionally evaluated as potential factors affecting SWS and IQR/M.

**Results:** Among 34 patients (21–70 years; mean, 42 years; male:female, 10:25; BMI range, 36–78; mean, 48), 18 (53%) had IQR/M of  $>0.30$ . Patients with SLT  $\geq 3$  cm had higher IQR/M than those with SLT of 3 cm ( $P < .05$ ). Not much difference was observed with BMI, age, gender, and hepatic steatosis. Although there was better visualization of liver parenchyma with 4V1 due to better penetration in 14 of 34 patients, there was no significant variation in the ARFI values or failure rate from the 6C1 probe. Eighteen patients (54%) showed high values (SWS  $>1.8$  m/s, documented for advanced fibrosis), and these high values did not exhibit a relationship with IQR/M. Additionally, SWS values were significantly different with BMI (mean BMI, 44 for SWS  $<1.8$  m/s; 52 for SWS  $\geq 1.8$  m/s) and SLT (mean SLT, 3.0 for SWS  $<1.8$  m/s; 3.7 for SWS  $\geq 1.8$  m/s).

**Conclusions:** SLT influenced the reliability of the shear wave velocity measurements. High SWS values were observed in patients with high BMI and SLT. High SWS values were not related to IQR/M values. Lower frequency of probe 4V1 by itself did not significantly alter the reliability of SWS measurements. Further technical advancement that improves the reliability of SWS measurements in the patients with morbid obesity would be helpful.

#### 2384949 Limitations and Artifacts in the Use of Shear Wave Elastography in the Liver

Matthew Bruce<sup>1</sup>, \*Giovanna Ferraioli<sup>2</sup>, Orpheus Kolokythas<sup>4</sup>, Dighe Manjiri<sup>2</sup>

<sup>1</sup>Applied Physics Laboratory, <sup>2</sup>Radiology, University of Washington, Seattle, WA USA; <sup>3</sup>Infectious Diseases, University of Pavia, Pavia, Italy; <sup>4</sup>Radiology, Kantonsspital Winterthur, Winterthur, Switzerland

**Objectives:** Liver biopsy is the standard of reference to assess and follow chronic liver disease. However, liver biopsy is an invasive procedure associated with drawbacks such as bleeding, pain, sampling error, and intraobserver/interobserver variability. The use of shear wave–based elastographic techniques has grown in use for the noninvasive assessment of fibrosis. However, shear wave elastographic (SWE) techniques also have limitations and artifacts. SWE imaging enables 2-dimensional quantitative visualization of tissue stiffness. Other approaches such as transient elastography (Echosens, Paris, France) or point-based shear wave approaches, available on several ultrasound systems, provide a single numerical stiffness estimate of a region. SWE imaging was used to characterize and contrast different artifacts and limitations between these techniques in estimating liver stiffness.

**Methods:** SWE imaging was used to assess liver stiffness in 204 patients (mostly hepatitis C and B) receiving biopsy and having varying levels of fibrosis and body habitus. Some of these patients also had one of the point-based shear wave techniques performed for comparison. SWE imaging and point-based approaches were acquired in different areas, including the area of the biopsy. The elastographic acquisitions were acquired prior to biopsy and compared with the resulting pathologic results using the METAVIR score.

**Results:** Artifacts observed with SWE techniques were composed of reverberation underneath the liver capsule, pulsations around larger vasculature, and artifacts associated with respiratory and cardiac motion. Cardiac motion and reverberation artifacts were encountered consistently in left lobe liver tissue stiffness measurements. Measurement bias was difficult to appreciate underneath the liver capsule with the point-based techniques. Ultrasound-associated limitations consisted of a compromised SWE signal due to poor acoustic windows and limits in penetration.

**Conclusions:** SWE-based techniques are proving to be useful alternatives to liver biopsy in assessing and following fibrosis. However, care is needed in the placement and acceptance of successful liver stiffness measurements to reduce measurement variability and biases, which could lead to misleading fibrosis assessments.

#### 2385195 Shear Wave Elastography of Liver: The Optimal Minimum Measurement Number for Different Fibrosis Stages—A Prospective Study

Qian Li, \*Manish Dhyani, Anthony Samir

Radiology, Massachusetts General Hospital, Boston, MA USA

**Objectives:** To explore the optimal minimum number of shear wave elastographic (SWE) stiffness measurements in liver fibrosis with different stages.

**Methods:** A total of 254 consecutive patients who underwent SWE before their scheduled liver biopsy (age 18–78 years; mean, 47.85 years; men, 115; women, 139) were enrolled in this study between August 2013 and January 2015. SWE values and biopsy specimens were obtained at the same area of the upper right lobe of the liver. Ten SWE measurements were acquired for each case, and median measurements were chosen for further analyses. Liver fibrosis was METAVIR staged by a blinded pathologist. Receiver operating characteristic (ROC) curves were constructed for distinguishing  $\geq F2$  fibrosis for 10 measurements and then sequentially for measurement numbers below 10.

**Results:** Study population fibrosis stages were F0 = 102, F1 = 93, F2 = 24, F3 = 26, and F4 = 9. For all subjects, the areas under the ROC curve (AUC) of the 10 measurements in differentiation of stage  $\geq F2$  and stage F4 were 0.832 (95% confidence interval [CI], 0.776–0.888) and 0.930 (95% CI, 0.886–0.974) respectively. The minimum measurement numbers in differentiation of corresponding fibrosis stages were 3 (AUC = 0.803; 95% CI, 0.739–0.867;  $P = .171$ ) and 7 (AUC = 0.934; 95% CI, 0.895–0.974;  $P = .528$ ) respectively. Further subset analyses showed that in subjects with hepatitis C virus (HCV), the AUCs of the 10 measurements in differentiation of stage  $\geq F2$  and stage F4 were 0.838 (95% CI, 0.775–0.901) and 0.930 (95% CI, 0.865–0.976), and optimal minimum measurement numbers in differentiation of corresponding fibrosis stages were 6 (AUC = 0.832; 95% CI, 0.767–0.897;  $P = .556$ ) and 5 (AUC = 0.919; 95% CI, 0.865–0.972;  $P = .460$ ), respectively.

**Conclusions:** Our study indicates that, in the patients with variety of hepatic diseases, the optimal minimum numbers of SWE measurements were 3 and 7 in differentiation of stages  $\geq F2$  and F4, whereas in patients with HCV, optimal minimum numbers were 6 and 5 in differentiation of stages  $\geq F2$  and F4.

#### 2385742 Identifying Clinically Significant Prostate Cancers Using 3-Dimensional In Vivo Acoustic Radiation Force Impulse Imaging With Whole-Mount Histologic Validation

Mark Palmeri, Tyler Glass, Zachary Miller, Stephen Rosenzweig, Andrew Buck, Thomas Polascik, Rajan Gupta, Alison Brown, John Madden, Kathryn Nightingale\*

Duke University, Durham, NC USA

**Objectives:** Overly-aggressive prostate cancer (PCa) treatment adversely affects patients and places an unnecessary burden on our health care system. The inability to identify and grade clinically significant PCa lesions is a contributing factor to excessively aggressive PCa treatment, such as radical prostatectomy, instead of more focal, prostate-sparing procedures such as cryotherapy and high-dose radiation therapy. In this study we assess the accuracy of acoustic radiation force impulse (ARFI) imaging for identifying clinically significant prostate cancer.

**Methods:** We have performed 3D in vivo B-mode and ARFI imaging using a mechanically rotated, side-fire endorectal imaging array to identify regions suspicious for PCa in 29 patients being treated with radical prostatectomies for biopsy-confirmed PCa. Whole-mount histopatho-



logic analyses were performed to identify regions of clinically significant/insignificant PCa lesions, atrophy, and benign prostatic hyperplasia. Regions of suspicion for PCa were reader identified in ARFI images based on boundary delineation, contrast, texture, and location. These regions of suspicion were compared to histopathology-identified lesions using a nearest-neighbor regional localization approach.

**Results:** A total of 71.4% of all clinically significant lesions identified on histopathology were also identified using ARFI imaging, including 79.3% of posterior and 33.3% of anterior lesions. A total of 79.3% of ARFI-identified lesions corresponded to clinically significant PCa lesions, with these lesions having higher indices of suspicion than clinically insignificant PCa.

**Conclusions:** This study has demonstrated that ARFI imaging has clinical value in identifying and differentiating clinically significant PCa lesions in the posterior region of the prostate, and advances in transducer technology and modified ARFI imaging sequences should allow the anterior region of the prostate to be more reliably interrogated in future studies.

### 2385755 Comparison of the Accuracy of Prostate Biopsy Guided by Grayscale Ultrasound and Real-time Elastography in Patients Selected by Different Methods of Assessing Prostate-Specific Antigen in the Diagnosis of Prostate Cancer

*Claudia Silva,\* David Shigueoka, Sergio Ajzen*

*Diagnóstico por Imagem, Universidade Federal de São Paulo, São Paulo, Brazil*

**Objectives:** To compare the accuracy of prostate biopsies guided by grayscale ultrasound (GSU) and real-time elastography (RTE) in predicting prostate cancer (PC) in men with increased levels of prostate-specific antigen (PSA) evaluated by different methods.

**Methods:** A total of 103 consecutive patients suspicious for prostate cancer underwent RTE-guided systematic biopsies from December 2012 to December 2013. Patients were selected in 3 groups: PSA levels between 2.5 and 10.0 ng/mL (group a); PSA density (PSAD) >0.15 ng/mL/cm<sup>3</sup> (group b), and PSA density in the transition zone (PSADZT) >0.35 ng/mL/cm<sup>3</sup> (group c). Each patient enrolled in the study underwent a 12-core prostate biopsy. Six lateral prostate sectors (base, mid, and apex) were scanned for cancer suspicious areas, defined as stiffer blue using RTE and hypoechoic using GSU. Suspicious areas were sampled by a single targeted biopsy and considered representative of a defined prostate sector. If RTE or GSU did not visualize a suspicious area in a sector, the biopsy core was taken systematically. Imaging findings were correlated with histopathologic reports. The results were compared in terms of cancer detection.

**Results:** Seventy-two patients were selected for group a, 45 for group b, and 46 for group c. Of the 103 patients, 41 (39.84%) had PC on histopathologic examination. In the groups, we detected 21 patients in group a (20.8%), 37 in group b (35.9%), and 38 in group c (36.8%) with positive biopsy results. Overall sensitivity was 100% for each group for RTE and 71.4%, 75.8%, and 78.5% for GSU. The specificity was 41.1%, 50.0%, and 44.4% for RTE and 70.5%, 56.2%, and 66.6% for GSU. The detection rate was significantly higher in patients selected by PSAD and PSADZT ( $P < .001$ ). The highest positive predictive value was found in patients selected by PSAD and with biopsy guided by RTE (78.3%).

**Conclusions:** Sensitivity to visualize and detect PC improved using RTE in addition to GSU for guiding prostate biopsies in all groups, but with lower specificity. The detection rate was higher in patients selected by PSAD and PSADZT, but there was no difference between these 2 groups. We concluded that targeted biopsy alone is not sufficient to replace the traditional systematic biopsy technique in patients selected by these 3 different methods of assessing PSA.

### 2385768 The Value of Shear Wave Elastography to Differentiate Benign From Malignant Thyroid Nodules

*Lucy Kerr,\* David Torricio*

*Sonimage dig Medico por US, São Paulo, Brazil*

**Objectives:** The aim of the study was to evaluate the diagnostic performance of shear wave (SW) and strain elastography (SE) and their combined use in differentiating thyroid nodules. This prospective study included 384 thyroid nodules in 183 patients, and 129 nodules had pathologic diagnoses (77 benign and 52 malignant). The purpose of this study was to evaluate the value of SE and the SW to differentiate benign from malignant thyroid nodules according to 2 criteria: (1) nodule stiffness and (2) differences in size between B-mode sonography (US) and elastography (E).

**Methods:** One hundred twenty-nine nodules were prospectively evaluated from September 2010 to August 2015 with high-resolution US using SW and SE with the AS-2000 (Siemens), and the diagnosis was correlated with histopathology. The nodules were grouped according to the stiffness in 5 patterns: (1)  $\geq 60\%$  soft; (2)  $\geq 60\%$  hard; (3)  $\geq 60\%$  intermediary; (4) same stiffness of thyroid parenchyma; (5) other combinations of stiffness. Patterns 1 and 4 were considered benign, 2 malignant, and 3 and 5 inconclusive. We also considered the finding benign if the nodule was bigger in B-mode US than E, malignant if bigger in E than B-mode US, and inconclusive if it had the same size in both.

**Results:** The sensitivity, specificity, positive predictive value, and negative predictive value were 84.2% (32/38), 93.6% (59/63), 88.8% (32/36), and 90.7% (59/65) using the stiffness criterion and 80.5% (29/36), 85.0% (17/20), 90.6% (29/32), and 70.8% (17/24) using the size criterion. We had 6 false negatives; all of them were papillary cancer with cystic soft content; and 4 false positives due to calcified or fibrotic benign nodules. Of 129, 28 (21.7%) nodules were classified as inconclusive by the stiffness criterion, half of them malignant, and 73 (56%) by the size criterion, 16 (22%) of them malignant.

**Conclusions:** SW and SE of suspicious thyroid nodules using the stiffness criterion are precise and helpful to differentiate between benign and malignant thyroid nodules, and we recommend that they be incorporated in clinical practice. The size criterion is less helpful due to many inconclusive cases despite good specificity and negative predict value.

## Gynecologic Ultrasound

*Moderator: Arthur Fleischer, MD*

### 2346589 Real-time Transvaginal Ultrasound Observation of Fallopian Tube Peristalsis in Patients With Acute Pelvic Inflammatory Disease

*Ronald Wachsberg*

*Radiology, University Hospital, Newark, NJ USA; Radiology, Rutgers New Jersey Medical School, Newark, NJ USA*

**Objectives:** In patients with pelvic inflammatory disease (PID), a thickened fallopian tube may be the only abnormality noted on transvaginal ultrasound (TVUS). The literature states that, if an indeterminate tubular structure is noted in the adnexa, the presence of peristalsis indicates that the structure is bowel, because fallopian tube peristalsis is not discernible on TVUS. The objective of this paper is to report the real-time TVUS observation of fallopian tube peristalsis in patients with acute PID.

**Methods:** A 1-year retrospective review was conducted of symptomatic women in whom TVUS findings were consistent with acute PID. Patients in whom peristalsis of a thickened (>5 mm diameter) fallopian tube was observed during real-time TVUS were identified, and their imaging studies were reviewed.

**Results:** Peristalsis was noted in 11 thickened fallopian tubes in 10 women with acute PID. Mean thickness of the affected tube was 10.7 mm (SD, 1.8 mm). The abnormal tube was on the right side in 6 patients, on the left side in 3 patients, and bilateral in 1 patient.

**Conclusions:** Fallopian tube peristalsis can be observed on real-time TVUS in acute PID. Therefore, if an otherwise indeterminate tubular adnexal structure is seen on TVUS, visible peristalsis does not indicate that the structure is not a fallopian tube.

#### 2374066 Correlation Between Transperineal Ultrasound and Urodynamic Findings in Patients With Lower Urinary Tract Symptoms After Midurethral Sling Placement

Peter Takacs<sup>1</sup>,\* Kindra Larson<sup>1</sup>, Lauren Scott<sup>1</sup>, Tina Cunningham<sup>2</sup>, Alfred Abuhamad<sup>1</sup>

<sup>1</sup>Obstetrics and Gynecology, <sup>2</sup>Center for Health Analytics and Discovery, Eastern Virginia Medical School, Norfolk, VA USA

**Objectives:** To evaluate dynamic 2D transperineal pelvic ultrasound (TPU) findings with urodynamic studies (UDS) in women with lower urinary tract symptoms (LUTS) after midurethral sling placement.

**Methods:** TPU and UDS were reviewed from women presenting to our center with a midurethral sling and LUTS from 12/2013 to 12/2014. TPU was carried out with the ultrasound probe positioned at the vaginal introitus. The midurethral sling was identified as the hyperechoic structure under the urethra. The shape and sonographic dynamic change of the sling from the rest position to maximum Valsalva and from maximum Valsalva back to rest were recorded. Patients were categorized into 3 groups: group 1 (G<sub>1</sub>), at rest the sling lies parallel to the urethral lumen, and during Valsalva the sling becomes c-shaped; group 2 (G<sub>2</sub>), both at rest and during Valsalva the sling runs parallel to the urethral lumen; group 3 (G<sub>3</sub>), at rest the sling is c-shaped, and during Valsalva this curved shape is maintained. For analytical purposes, G<sub>3</sub> was compared to G<sub>1+2</sub>. Multiple logistic regressions were used to evaluate the association between TPU and UDS.

**Results:** Seventy-seven women were enrolled. There were no significant demographic differences between the groups. The detrusor pressure at the maximum flow rate (P<sub>det</sub> Max) was significantly higher in G<sub>3</sub> compared to G<sub>1+2</sub> (36 ± 16 vs 19 ± 11 mm H<sub>2</sub>O; *P* < .001). A significant association was noted between G<sub>3</sub> and high detrusor pressure (P<sub>det</sub> Max > 20 mm H<sub>2</sub>O) compared to patients in G<sub>1+2</sub>. The odds of high P<sub>det</sub> Max among those in G<sub>3</sub> was approximately 12 times the odds of among those in G<sub>1+2</sub>. After adjusting for other variables using multiple logistic regression analysis, a statistically significant association between G<sub>3</sub> and high P<sub>det</sub> Max (odds ratio, 29.7; 95% confidence interval, 2.95–299.6; *P* = .004) persisted. Sensitivity, specificity, and positive and negative predictive values of high P<sub>det</sub> Max in G<sub>3</sub> were 57%, 89%, 84%, and 68%, respectively.

**Conclusions:** This is the first report of a correlation between 2D dynamic TPU and UDS. Transperineal dynamic 2D ultrasound can help predict women with high-pressure voiding after a midurethral sling and thus aid in the diagnosis of bladder outlet obstruction.

#### 2374870 Emergency Department Utilization of Pelvic Ultrasound and Computed Tomographic Studies in Women Presenting With Lower Abdominal or Pelvic Pain

Natalie Adams<sup>1</sup>,\* Dale Stovall<sup>1</sup>, Virginia Stewart<sup>2</sup>

<sup>1</sup>Obstetrics and Gynecology, <sup>2</sup>Emergency Medicine, Riverside Health System, Newport News, VA USA

**Objectives:** To determine which characteristics are associated with the selection of either a radiology- or emergency physician-performed ultrasound (U/S) or a computed tomographic (CT) imaging study in non-pregnant women presenting to the emergency department (ED) with lower abdominal or pelvic pain.

**Methods:** This was a retrospective study performed at a regional level 2 Trauma center ED from January 2013 to April 2015. Female patients with a chief complaint or diagnosis of either lower abdominal or pelvic pain who had either a radiology-performed CT scan or U/S or an archived emergency physician-performed transvaginal U/S scan were in-

cluded. Patients were excluded if they had trauma or orthopedic injury, positive pregnancy, upper gastrointestinal etiologies, sepsis, known neoplastic disease, and renal etiologies. All CT and radiology-performed U/S images were interpreted by board-certified radiologists. All ED-performed U/S scans were interpreted at bedside by credentialed emergency physicians. This study received a full review and approval by the Institutional Review Board.

**Results:** Of the patients imaged, 49 met all eligibility requirements and were included in the study. The mean age of study participants was 32 years (range, 19–60 years). In the study population, a total of 15 CT scans, 10 radiology-performed U/S scans, and 31 emergency physician-performed U/S scans were performed. There were no discrepancies between the ED- and radiology-performed U/S reported results. Eight (53.3%) of the 15 CT scans and 27 (65.9%) of the 41 U/S scans performed were positive studies. U/S was not significantly more likely to be performed between the hours of 0800 and 2000 compared to 2000 and 0800 (30/37 [81.1%] vs 12/19 [63.2%]; *P* = .19). However, a history or diagnosis of vaginal bleeding was significantly associated with the performance of a U/S scan as compared to imaging by CT scan (14/15 [93.3%] vs 1/15 [6.7%], respectively; *P* < .05).

**Conclusions:** U/S imaging, especially ED physician-performed U/S, was highly utilized in our study population who presented with either lower abdominal or pelvic pain. A history of vaginal bleeding was significantly associated with the type of imaging modality selected, but time of day was not.

#### 2383686 HDliveFlow With HDlive Silhouette Mode for Diagnosis of Uterine Disorders

Kenta Yamamoto,\* Mohamed AboEllail, Tamaki Tanaka, Masato Mashima, Emiko Nitta, Kenji Kanenishi, Toshiyuki Hata

Perinatology and Gynecology, Kagawa University, Takamatsu, Kagawa, Japan

**Objectives:** We present our experiences with uterine disorders reconstructed using HDliveFlow with the HDlive silhouette mode.

**Methods:** Six cases (1 case each of uterine artery pseudoaneurysm [UAP], complete mole, and hydropic degeneration in missed abortion, and 3 cases of uterine fibroids) were studied using HDliveFlow with the HDlive silhouette mode.

**Results:** In cases of uterine fibroids, 3 patterns of blood flow were demonstrated. In 1 case, abundant blood flow inside the fibroid was noted. In another case, a moderate blood flow pattern was observed inside the tumor. In the third case, vascularity inside the tumor was poor, with identification of circular blood vessels around the fibroid resembling the classic belief about fibroid vascularity. A spatial view of the distribution of these vessels within the fibroid as well as their relation to clearly seen uterine vasculature was achieved. In the case of hydropic degeneration on missed abortion, several small vesicles surrounded by the abundant uterine blood flow were clearly seen, while the numerous vesicles without blood flow in the uterine cavity formed the characteristic shape of a complete mole. In the case of UAP, a spatial “yin-yang sign” or “shell-like appearance” with identification of the feeder artery was visualized.

**Conclusions:** HDliveFlow with the HDlive silhouette mode should provide new insight into the patterns of vascularity in different uterine disorders. This would be beneficial in diagnosing and differentiating these lesions and therefore providing proper management.

### 2384737 Surgical Correction of Uterine Subseptations Reestablishes Standard Uterine Cavity Measurements

Laura Detti,\* Mary Christiansen

Obstetrics and Gynecology, University of Tennessee Health Science Center, Memphis, TN USA

**Objectives:** Existing ultrasound guidelines identify the uterus as normal if its length is 8 cm, height is 4 cm, and width is 5.0 cm; however, there is no clear definition of the normal uterine cavity dimensions. Our group previously defined the uterine and uterine cavity dimensions of subseptate uteri and their postoperative uterine remodeling. With this study we sought to define the uterine cavity dimensions of normal uteri with 3D ultrasound and compare them to those obtained in subseptate uteri before and after hysteroscopic surgical resection.

**Methods:** This was a prospective cohort study. Measurements of the cavity width, length, and area were obtained with 3D ultrasound on a frozen coronal view of the uterus in normal and in subseptate uteri before and after surgical resection by hysteroscopy. Paired and unpaired *t* tests were used for comparisons (SPSS version 22).

**Results:** One hundred eighty patients were included in the study: 90 in the normal and 90 in the subseptate uterus groups. Preoperative uterine length and height were similar in the preoperative and postoperative subseptate uteri and in the normal uteri, while uterine width was significantly greater in the preoperative ( $5.1 \pm 0.8$  cm) than postoperative ( $4.7 \pm 0.9$  cm) groups and normal uteri ( $4.6 \pm 0.7$  cm;  $P < .001$ ). The preoperative uterine cavity length ( $3.4 \pm 0.5$  cm), width ( $3.2 \pm 0.7$  cm), and area ( $4.6 \pm 1.4$  cm<sup>2</sup>), were significantly greater than the postoperative ones (length,  $2.9 \pm 0.6$  cm; width,  $2.6 \pm 0.7$  cm; area,  $3.8 \pm 1.1$  cm; overall  $P < .015$ ), which became similar to the normal uteri (length,  $3.1 \pm 0.6$  cm; width,  $2.6 \pm 0.6$  cm; area,  $4.0 \pm 1.4$  cm<sup>2</sup>;  $P =$  not significant).

**Conclusions:** To our knowledge, this is the first study to define the 3D ultrasound dimensions of the uterine cavity in normal and subseptate uteri and their change after surgical correction. Uterine cavity length, width, and area show very little variation in adult normal uteri, but they are increased in subseptate uteri. Once surgical correction occurs, the cavity remodels to regain a shape and size similar to normal uteri.

### 2388879 A Tale of Two Hospitals

Ixora Atan<sup>1</sup>, Jessica Hall<sup>1</sup>, Susanne Langer<sup>1</sup>, Ka Shek<sup>2</sup>, Hans Dietz<sup>1\*</sup>

<sup>1</sup>University of Sydney, Penrith, New South Wales, Australia;

<sup>2</sup>Western Sydney University, Liverpool, New South Wales, Australia

**Objectives:** Maternal birth trauma has become an increasing concern in recent years. Our aim was to determine the association between variations in obstetric practice between two tertiary hospitals and such trauma. Primary outcome measures were sonographic levator ani muscle (LAM) avulsion and external anal sphincter (EAS) trauma.

**Methods:** This was a secondary analysis of a prospective study on 660 women with an uncomplicated singleton pregnancy. Offline analysis of ultrasound (US) volume data was performed blinded against all other data. Avulsion was defined as an abnormal muscle insertion observed in at least 3 central tomographic (TUI) slices. A “significant EAS defect” is defined as a gap of  $\geq 30^\circ$  in its circumference, in at least 4 of 6 central TUI slices.

**Results:** Of 660 women recruited, 504 (76%) returned for postpartum review at a mean interval of 5.1 (range, 2.3–22.4) months. Two were excluded, due to missing postpartum US volumes in 1 and an intercurrent birth in another, leaving 502. Assessment of avulsion was possible in all women. Assessment of EAS integrity was possible in 488. Of the 502 women, 116 (23%) were delivered by cesarean section; 386 (77%) delivered vaginally, by normal vaginal delivery in 280 (56%), vacuum in 70 (14%), and forceps in 36 (7%). We evaluated the incidence of maternal trauma in those delivered vaginally. There was a significant difference in

the incidence of LAM avulsion (Table 1). On multivariate binary logistic regression modeling, the association between delivery centers and incidence of LAM avulsion became nonsignificant. Body mass index (BMI), length of the second stage, and forceps delivery were predictors of the difference in the incidence of LAM avulsion between the hospitals, with forceps delivery being the strongest (adjusted odds ratio [OR], 5.2; 95% confidence interval [CI], 2.3–12.1;  $P < .001$ ).

**Conclusions:** We found a significant difference in the incidence of LAM avulsion between two tertiary centers, explained by the differences in maternal BMI, length of the second stage, and rate of forceps, the latter being the strongest predictor of LAM avulsion.

Table 1. Incidence of Maternal Birth Trauma in Two Tertiary Obstetric Units

	Hospital A (n = 165)	Hospital B (n = 221)	OR (95% CI)	P
Levator avulsion	19/165 (11.5%)	47/221 (21.3%)	2.1 (1.2–3.7)	.01
EAS defect	32/159 (20.1%)	53/217 (24.4%)	1.3 (0.8–2.1)	.33

### 2388952 Normal Values of Anal Sphincter Biometry by 4-Dimensional Pelvic Floor Ultrasound

Julie Magpoc, Ixora Atan, Hans Dietz\*

University of Sydney, Penrith, New South Wales, Australia

**Objectives:** Translabial ultrasound (TLUS) can provide a non-invasive alternative to endoanal ultrasound in the investigation of obstetric anal sphincter trauma. We aimed to define limits of normality for dimensions of external and internal anal sphincters (EAS and IAS).

**Methods:** This study involved primigravid women seen prospectively for 4D TLUS at a mean gestation of 36 (range, 32.9–37.3) weeks. TLUS was performed supine at rest and on pelvic floor muscle contraction (PFMC). Offline analysis of volume data was done blinded against all other data. Sphincter assessment was performed on tomographic ultrasound imaging (TUI). EAS length (ventral and dorsal) was measured in the midsagittal plane. EAS thickness was measured at the 12- and 6-o’clock positions in the axial plane. EAS rotational asymmetry was defined as the distance between ventral and dorsal EAS cranial terminations, measured in the midsagittal plane at maximal PFMC.

**Results:** A test-retest series ( $n = 20$ ) showed good repeatability of all measures (intraclass correlation coefficient, 0.62–0.85). One hundred twelve women were seen. One was excluded due to missing volume data, leaving 111. The majority were Caucasian ( $n = 77$  [69%]) with a mean age of 30.9 (range, 18.8–40.5) years. On TUI, EAS defects were noted in 12% ( $n = 13$ ), affecting a maximum of 3/6 slices. IAS defects were noted in 7% ( $n = 8$ ) in a maximum of 3 slices. None of the 111 women fulfilled published minimal criteria for the diagnosis of significant EAS/IAS defects. Mean measured EAS length was 17.5 (range, 8.4–34.8) mm. The EAS was shorter dorsally at a mean length of 16.4 (range, 7–32.7) mm compared to ventral EAS length of 18.7 (range, 7.5–36.9) mm ( $P < .001$ ). The mean difference in EAS length was 2.3 (range, –6.4–9.7) mm. The ventral EAS was observed to reach further cranially than the dorsal EAS, resulting in a positive mean rotational cranial asymmetry of 0.8 (range, –4.8–5.1) mm. Mean EAS thickness was 3.4 (range, 2.0–5.8) mm, being thicker dorsally ( $P < .001$ ). IAS thickness did not vary much.

**Conclusions:** Sonographic measures of sphincter biometry can be assessed with good repeatability by translabial 3D/4D ultrasound. The likelihood of a false-positive diagnosis of a “significant defect of EAS/IAS” on using the published tomographic method seems very low.



**2388999 Does Patient Posture Affect Sonographic Evaluation of Pelvic Organ Prolapse?**

**Meirav Braverman, Friyan Turel, Talia Friedman, Ixora Atan, Hans Dietz\***  
*University of Sydney, Penrith, New South Wales, Australia*

**Objectives:** Translabial ultrasound (TLUS) is an established method for the evaluation of female pelvic organ prolapse (FPOP). It is usually assessed supine, and published normative data apply to that position. We evaluated the effect of posture change on commonly measured parameters.

**Methods:** This was a prospective study on 175 women seen in a tertiary urogynecologic center for symptoms of pelvic floor dysfunction. All women underwent 4D TLUS supine and standing. Both of prolapse symptoms was quantified by a visual analog scale. “Clinically significant prolapse” was defined as International Continence Society (ICS) Pelvic Organ Prolapse Quantification System stage 2 or higher in any compartment. Offline measurements of cystocele, uterine descent, descent of the rectal ampulla, and hiatal area on Valsalva were undertaken at a later date, blinded against all other data. Measurements were performed on volume data sets obtained on maximal Valsalva in the supine and standing positions.

**Results:** Mean age was 58 (range, 17–89; SD, 13.48) years. Mean body mass index was 29 (range, 18–29; SD, 6.13) kg/m<sup>2</sup>. Fifty-nine percent (n = 103) presented with symptoms of prolapse. Clinically, 83% (n = 146) had significant prolapse of ICS stage 2 and above in any compartment. We obtained receiver operating characteristic statistics to define the correlation between symptoms of prolapse and TLUS measurements in supine and standing positions. For most measures, the area under the curve was nonsignificantly higher in the standing position; organ descent was significantly higher (Table 1).

**Conclusions:** Measurements of organ descent on Valsalva and hiatal dimensions in the standing position are generally higher than supine. The association between symptoms and organ descent is nonsignificantly stronger in the standing position, but we feel that the difference is too trivial to warrant the additional effort that is required for patients and examiners.

Table 1. Pelvic Organ Descent and Hiatal Area on Valsalva in Supine and Standing Positions

	Supine, Mean (SD)	Standing, Mean (SD)	Mean Difference, β (95% CI)	P
Cystocele, mm	−3.4 (17.30)	−8.72 (16.69)	5.33 (3.54 to 7.11)	<.001
Uterine descent, mm	7.74 (19.35)	3.38 (19.86)	4.36 (1.23 to 7.49)	.007
Descent of rectal ampulla, mm	−9.1 (12.78)	−11.21 (11.66)	2.11 (0.27 to 3.95)	.03
Hiatal area on Valsalva, cm <sup>2</sup>	28.11 (8.69)	33.68 (9.84)	−5.57 (−6.39 to −4.76)	<.001

CI indicates confidence interval.

**2392508 Translabial Ultrasound for the Assessment of Pelvic Floor Injury in Women Who Used a Novel Semiautomated Pelvic Floor Dilator During Active Labor**

**Susan Ramin<sup>1</sup>, \* Francisco Orejuela<sup>1</sup>, Wesley Lee<sup>1</sup>, Rajshi Gandhi<sup>1</sup>, Lauren Mack<sup>1</sup>, Hans Dietz<sup>2</sup>**

*<sup>1</sup>Obstetric and Gynecologic Ultrasound, Baylor College of Medicine, Houston, TX USA; <sup>2</sup>University of Sydney, Nepean, New South Wales, Australia*

**Objectives:** Translabial ultrasound (TLUS) is an accurate and noninvasive method to assess the pelvic floor but not commonly used in current obstetric practice. This study evaluates sonographic signs of pelvic floor injury using TLUS in women who used a novel semiautomated pelvic floor dilator during the active phase of labor.

**Methods:** A pilot study of women in whom a novel semiautomated pelvic floor dilator (Materna Medical, San Francisco, CA) was used during the active phase of labor. Inclusion criteria were healthy primiparas with singleton pregnancies in a cephalic presentation and planned labor epidural. At 36 weeks' gestation, patients had a baseline 4D TLUS examination with pelvic examination. We used dynamic imaging to evaluate the pelvic floor during Valsalva and contraction. The levator and external anal sphincter (EAS) were evaluated using tomographic ultrasound imaging (TUI). EAS defects were defined as disruption of the muscle seen during contraction in 4 or more of the TUI slices. Images were obtained by a single registered sonographer and reviewed individually by 2 urogynecologists who were blinded to the clinical information. This was followed by a similar evaluation at 12 weeks' postpartum by the same urogynecologists who were blinded to the course of labor and delivery. The device was inserted in the vaginal introitus to achieve a preset pelvic floor dilation of 8 cm, ideally over a 30–60-minute time period.

**Results:** The device was used in 21 patients who met study criteria. Of these patients, 18 delivered vaginally, and 3 delivered by cesarean for obstetric indications. There were no pelvic floor abnormalities identified on the baseline TLUS. Postpartum TLUS has been completed in 14 patients. There were no levator ani injuries, but 2 patients had a partial EAS tear. None of the patients exhibited ballooning of the levator hiatus postpartum.

**Conclusions:** Four-dimensional TLUS can be used to identify and characterize delivery-related pelvic floor injuries in pregnant and postpartum women.

**2385262 Heterotopic Pregnancy: Case Series and Review of the Literature**

**Usha Verma, Juliana Martins\***

*Obstetrics and Gynecology, University of Miami, Miami, FL USA*

**Objectives:** To report early diagnosis, management, and outcomes of 13 cases of heterotopic pregnancies from 2004–2015 at Jackson Memorial Hospital, Miami.

**Methods:** This is a case series and a review of the literature of 13 cases of heterotopic pregnancies.

**Results:** Of all cases, 50% were in vitro fertilization pregnancies, and the rest were spontaneous conception. Of 13 heterotopic pregnancies, 8 were cervical, 2 were tubal, 2 were in the cesarean section scar, and 1 was interstitial in association with an intrauterine pregnancy. Four patients were lost to follow-up, 2 continued pregnancy until later gestation, 3 had pregnancy loss in the second trimester, 3 terminated both pregnancies, and 1 is still pregnant. Patients whose fetuses had cardiac activity in the ectopic pregnancy were successfully treated with potassium chloride, 3 patients received methotrexate as they wanted to terminate both pregnancies, 1 patient had no treatment with spontaneous resolution, and 2 had surgical treatment for ectopic pregnancy.

at 45 mm. Human-subject scans revealed images of the full globe, at 4 frames per second and 55-dB dynamic range, including features in the vitreous that would not normally be resolved.

**Conclusions:** An ophthalmic system using an annular array packaged in a handheld probe was demonstrated for clinical use on human subjects. Higher frame rates and signal-to-noise ratios are feasible, but the selected handheld probe was a limiting factor. The ability to image the full globe, including the vitreous, will open up new methods of diagnosis.

#### 2385719 Molecular Imaging With Dual-Targeted Microbubbles for Characterization of Sentinel Lymph Nodes

**Kartikeya Puranik<sup>1,2</sup>, \* Maria Stanczak<sup>1</sup>, Flemming Forsberg<sup>1</sup>, Ji-Bin Liu<sup>1</sup>, John Eisenbrey<sup>1</sup>, Andrej Lyshchik<sup>1</sup>**

<sup>1</sup>Radiology, Thomas Jefferson University, Philadelphia, PA USA; <sup>2</sup>School of Biomedical Engineering, Sciences, and Health Systems, Drexel University, Philadelphia, PA USA

**Objectives:** To characterize sentinel lymph nodes (SLNs) in a melanoma swine model using molecular imaging with dual-targeted contrast-enhanced ultrasound (CEUS).

**Methods:** Six Sinclair swine with naturally occurring melanoma (3–7 kg; Sinclair Bio-Resources, Columbia, MO) were studied with molecular CEUS. The contrast agent Targestar, SA (Targeson, San Diego, CA) was labeled with P-selectin and  $\alpha_{v\beta 3}$ -integrin antibodies to create dual-targeted microbubbles. Immunoglobulin G (IgG) antibody-labeled microbubbles were used as a control. SLNs were identified and marked after an intratumoral injection of 0.25 mL of Sonazoid (GE Healthcare, Oslo, Norway) using an S3000 scanner (Siemens Medical Solutions, Mountain View, CA) with a 9L4 probe. Nonsentinel lymph nodes (LNs) were identified with ultrasound in the areas distant from the tumor. After a 1-hour interval, targeted and control microbubbles were injected intravenously with a 30-min interval between injections. Targeted bubbles were allowed to circulate for 4 minutes to facilitate binding. Then, 2 sets of images before and after a high-power destruction sequence were acquired. The average video intensity pre to post destruction was measured as a relative measure of contrast retention in the LNs. All examined LNs were removed and histologically examined for the presence of metastatic involvement. Results were compared using *t* tests.

**Results:** A total of 11 SLNs and 13 nonsentinel LNs were imaged. Metastatic involvement greater than 5% was detected in 7 SLNs. The mean signal intensity of the dual-targeted contrast agent in the metastatic SLNs ( $17.2 \pm 15.8$ ) was significantly higher than the IgG-targeted control ( $1.5 \pm 1.3$ ;  $P = .036$ ). The signal intensity of dual-targeted and IgG-control microbubbles in benign LNs was not significantly different ( $1.5 \pm 0.8$  vs  $1.6 \pm 1.6$ ;  $P = .87$ ). There was a significant difference in dual-targeted contrast retention in metastatic vs benign LNs ( $P = .04$ ). However, the IgG-targeted control contrast agent demonstrated no significant retention difference in metastatic vs benign LNs ( $P = .88$ ).

**Conclusions:** Microbubbles targeted to P-selectin and  $\alpha_{v\beta 3}$ -integrin demonstrate significant retention in metastatic SLNs in a melanoma model, validating the use of molecular CEUS for in vivo characterization of SLNs.

#### 2381914 Effect of Pulse Shaping on Subharmonic-Aided Pressure Estimation

**Iphita Gupta<sup>1,2</sup>, \* John Eisenbrey<sup>1</sup>, Maria Stanczak<sup>1</sup>, Anush Sridharan<sup>1,3</sup>, Jaydev Dave<sup>1</sup>, Ji-Bin Liu<sup>1</sup>, Christopher Hazard<sup>4</sup>, Xinghua Wang<sup>5</sup>, Ping Wang<sup>6</sup>, Huiwen Li<sup>7</sup>, Kirk Wallace<sup>4</sup>, Flemming Forsberg<sup>1</sup>**

<sup>1</sup>Radiology, Thomas Jefferson University, Philadelphia, PA USA; <sup>2</sup>School of Biomedical Engineering, Sciences, and Health Systems, <sup>3</sup>Electrical and Computer Engineering, Drexel University, Philadelphia, PA USA; <sup>4</sup>GE Global Research, Niskayuna, NY USA; <sup>5</sup>Ultrasound, Second Hospital of Shanxi Medical University, Taiyuan, China; <sup>6</sup>Ultrasound, Affiliated Hospital of North Sichuan Medical College, Nanchong, China; <sup>7</sup>Ultrasound, Erdos Center Hospital, Erdos, China

**Objectives:** To analyze the effect of pulse shape on the sensitivity of subharmonic-aided pressure estimation (SHAPE) in vitro and in vivo.

**Methods:** Eight different pulse waveforms were implemented on a LOGIQ 9 scanner (GE, Milwaukee, WI) with a 4C curvilinear array and studied for SHAPE. A power optimization algorithm implemented on the LOGIQ 9 scanner was used for selecting optimum power for maximum SHAPE sensitivity. In vitro, the subharmonic amplitude of the contrast agent Sonazoid (GE, Oslo, Norway) was measured from 0–40 mm Hg in a sealed water tank. Radiofrequency data at 2.5 MHz were acquired following injection of Sonazoid (0.2 mL/L). Linear regression analysis was used to determine the relationship between hydrostatic pressure and change in amplitude for the subharmonic signal (at 1.25 MHz). Three canines were studied in vivo. Simultaneous pressure measurements were performed with a 5F high-fidelity manometer-tipped pressure catheter (SPC-350; Millar Instruments, Houston, TX) and the LOGIQ 9 scanner modified to perform SHAPE. Data were then collected, in triplicate at least 5 seconds, from the portal vein before and after induction of portal hypertension (by embolization of the liver microcirculation through injection of Gelfoam) during infusion of Sonazoid. Subharmonic data were extracted and compared to pressures obtained with the Millar catheter.

**Results:** A linear decrease in subharmonic amplitude with increased pressure was observed for all waveforms ( $r = -0.77$  to  $-0.93$ ;  $P < .001$ ) in vitro. The highest correlation was achieved with a Gaussian-windowed binomial filtered square wave. One of the 3 dogs was eliminated for technical reasons, while the other 2 produced very similar results to those obtained in vitro ( $r = -0.72$  to  $-0.98$ ;  $P < .01$ ). The most consistent in vivo results were achieved with the Gaussian-windowed binomial filtered square wave ( $r = -0.95$  and  $-0.96$ ).

**Conclusions:** Pulse shaping can greatly improve the sensitivity of SHAPE. Results indicate that a Gaussian-windowed binomial filtered square wave gives the highest correlation between changes in subharmonic amplitude of the microbubbles and ambient pressure changes.

#### 2384729 Logistic Regression Analysis of Contrast-Enhanced Ultrasound and Conventional Ultrasound Characteristics of Subcentimeter Thyroid Nodules

**Ruina Zhao, \* Bo Zhang, Xiao Yang, Yuxin Jiang, Xingjian Lai, Xiaoyan Zhang**

Peking Union Medical College Hospital, Beijing, China

**Objectives:** The purpose of the study described here was to determine specific characteristics of thyroid microcarcinoma (TMC) and explore the value of contrast-enhanced ultrasound (CEUS) combined with conventional ultrasound (US) in the diagnosis of TMC.

**Methods:** Characteristics of 63 patients with TMC and 39 with benign subcentimeter thyroid nodules were retrospectively analyzed. Multivariate logistic regression analysis was performed to determine independent risk factors.

**Conclusions:** Successful management of heterotopic pregnancy remains a challenge given the lack of current guidelines. The principle remains the safe and effective removal of the ectopic pregnancy while protecting the intrauterine pregnancy and preserving fertility. A sonographer may be falsely reassured by visualization of an intrauterine gestation, and an adnexal mass can be interpreted incorrectly as a corpus luteum cyst. This diagnosis should be considered in any patient with risk factors, and a careful ultrasound examination of the uterus and adnexa should be performed to allow early detection and management. The treatment approach should be tailored such as not to jeopardize the intrauterine pregnancy.

## High-Frequency and Contrast-Enhanced Ultrasound

*Moderator: Jonathan Mamou, PhD*

### 2380525 Acoustic Impedance of Bowman's Layer as a Possible Indication of Keratoconus

**Raksha Urs<sup>1,\*</sup>, Timothy Archer<sup>2</sup>, Dan Reinstein<sup>2</sup>, Ronald Silverman<sup>1,3</sup>**

<sup>1</sup>Ophthalmology, Columbia University Medical Center, Teaneck, NJ USA; <sup>2</sup>London Vision Clinic, London, United Kingdom; <sup>3</sup>Riverside Research, New York, NY USA

**Objectives:** Keratoconus (KC) is a disease characterized by progressive corneal thinning and reduced corneal rigidity, leading to loss of visual acuity and possibly eventual corneal transplant to salvage the eye. At present, most techniques for identification of KC are based on anatomy, eg, surface topography or pachymetry. Bowman's layer, a 12–15- $\mu$ m thick basement membrane at the interface of the epithelium and stroma, is known to thin and have altered collagen fibers in early KC, changes that may be causative. In this study, we investigated Bowman's layer acoustic impedance, a property related to biomechanics rather than anatomic structure.

**Methods:** Both eyes of 12 normal and 12 KC subjects were scanned with the Artemis arc-scan system at 35 MHz. Artemis acquires a radial set of scans while maintaining normality and range to the corneal surface. We treated the anterior surface of the cornea (the epithelium) as a specular reflector and deconvolved the radiofrequency data against this signal along each vector. Impedance was determined as Bowman's reflectivity relative to that of the epithelial surface.

**Results:** Results showed that in normal corneas, Bowman's relative impedance (Zbr) was quite uniform in distribution, even where epithelial thickness was nonuniform. Interestingly, we found that, in normal corneas, while Zbr varied from subject to subject, it was always the same in both eyes of a given subject. Zbr, however, was nonuniform in KC corneas, showing significantly elevated values paracentrally.

**Conclusions:** Acoustic impedance of Bowman's layer is nonuniform in KC. Further investigation is required to determine the utility of this parameter as a means for identification of early KC.

### 2384224 Twenty-Megahertz Coherent Compound Plane Wave Imaging of the Eye

**Ronald Silverman<sup>1,2,\*</sup>, Raksha Urs<sup>1</sup>, Daniel Gross<sup>2</sup>, Jeffrey Ketterling<sup>2</sup>**

<sup>1</sup>Ophthalmology, Columbia University Medical Center, New York, NY USA; <sup>2</sup>Riverside Research, New York, NY USA

**Objectives:** Ophthalmic ultrasonography is almost exclusively performed using mechanically scanned, single-element transducers. This limits image rates to <20 Hz and precludes Doppler or color flow imaging. High frame rates are useful for capturing saccade-induced vitreous motion and blood flow. While conventional linear arrays can address these needs, acoustic intensity is often too high to meet the ophthalmic 510k standard, the most stringent for any organ. Our objective was to develop

plane wave imaging methods for imaging the eye that would address the above limitations of mechanically scanned single-element probes and conventional linear arrays.

**Methods:** We measured ultrasound intensity as a function of range and excitation voltage for a Verasonics L22-14v high-frequency probe using a needle hydrophone calibrated to 60 MHz. Measurements were made in the scanned, focused mode (f2 focal ratio) and in the plane wave mode. Using parameters compatible with Food and Drug Administration (FDA) ultrasound exposure limits for the eye, coherent plane wave scans were performed on human subjects through both closed and open lids using the L22 probe with the Verasonics Vantage-128 system. Plane wave Doppler was used to capture blood flow.

**Results:** With 15-V excitation, derated spatial-peak pulse-average intensities ( $I_{SPPA,3}$ ) recorded at the elevation focus ( $\approx 7$  mm) were 318 and 27.4 W/cm<sup>2</sup> for focused and plane wave modes, respectively. Corresponding mechanical index values were 0.87 and 0.22 for focused and plane wave modes. Plane wave values at this voltage were just within the FDA limits for the eye. Scans performed with compound coherent plane wave (7 angles over  $\pm 18^\circ$  at 500 Hz/image) readily demonstrated blood flow in the major orbital vessels, the choroid, and retinal vessels. (Derated spatial-peak temporal-average intensity [ $I_{SPTA,3}$ ] was within FDA guidelines at this frame rate.)

**Conclusions:** Compound coherent plane wave imaging allows depiction of anatomy and perfusion at acoustic intensity values compliant with stringent FDA requirements for ophthalmic imaging, which was not the case for the conventionally focused array at the same voltage. This modality will have immediate research and clinical applications in conditions such as glaucoma and macular degeneration.

### 2385414 Handheld Real-time 20-MHz Ophthalmic Imaging With an Annular Array

**Jeffrey Ketterling<sup>1,\*</sup>, Daniel Gross<sup>1</sup>, Jonathan Mamou<sup>1</sup>, Kathleen Smith<sup>2,3</sup>, Quan Hoang<sup>2</sup>, Ronald Silverman<sup>1,2</sup>**

<sup>1</sup>Lizzi Center for Biomedical Engineering, Riverside Research, New York, NY USA; <sup>2</sup>Ophthalmology, Harkness Eye Institute, Columbia University Medical Center, New York, NY USA; <sup>3</sup>Örebro University, Örebro, Sweden

**Objectives:** Single-element ultrasound systems are the standard for clinical ophthalmic imaging. Annular arrays permit image quality of a linear array without the system complexity and cost. Here, improvements were made to a previous immersion scan prototype. The new system employs a handheld probe with a 20-MHz annular array that permits contact scanning.

**Methods:** A commercial handheld probe was modified so that a custom 5-element annular array could be mounted inside the probe. The array was based on a 25- $\mu$ m P(VDF-TrFE) membrane with a focal length of 25.8 mm and an aperture of 9 mm. The array was excited with a 5-channel pulser/receiver, and a 4-channel PCIe digitizer card recorded the echo signals for real-time image formation. The elements had a 22-MHz center frequency and  $\approx 37\%$  –6-dB fractional bandwidth. Acoustic pressures of each array element were characterized to ensure safe operating limits, and the acoustic beam was evaluated using a 25- $\mu$ m-diameter wire target. The cabling to the array elements was routed through a water-tight channel that was part of an attachment that slid over the end of the handheld probe. The attachment could be sealed with a membrane to create a water-tight chamber inside which the array translated. The membrane was then placed in contact with the eye for an ultrasound exam.

**Results:** Peak acoustic pressures were within 510k safety limits (mechanical index <0.14 and spatial-peak pulse-average intensity <5.5 W/cm<sup>2</sup>). The array was used in a synthetic-focusing mode with single-transmit to multiple-receive combinations. Due to limitations with the probe, frame rate and time intervals between scan lines, only 3 elements (1, 3, and 5) were used on transmit and 4 on receive (1–4). Beam widths measured with the wire target ranged from 0.16 mm at 16 mm to 0.42 mm



**Results:** Four variables were included in the logistic regression models: age, shape, blood flow distribution, and enhancement pattern. The area under the receiver operating characteristic curve was 0.919. With 0.113 selected as the cutoff value, the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were 90.5%, 82.1%, 89.1%, 84.2%, and 87.3%, respectively. Independent risk factors for TMC determined with the combination of CEUS and conventional US were age, shape, blood flow distribution, and enhancement pattern. Age was negatively correlated with malignancy, whereas shape, blood flow distribution, and enhancement pattern were positively correlated.

**Conclusions:** The logistic regression model involving CEUS and conventional US was found to be effective in the diagnosis of sub-centimeter thyroid nodules.

## Pediatric Ultrasound and Neurosonology

*Moderator: Rob Goodman, MD, BCHir*

### 2367190 Validation of a Low-Cost Optic Nerve Sheath Phantom: An Educational Tool

*David Murphy<sup>1,\*</sup>, Stephanie Oberfoell<sup>2</sup>, Andrew French<sup>2</sup>, Stacy Trent<sup>1,2</sup>, David Richards<sup>1,2</sup>*

<sup>1</sup>University of Colorado, School of Medicine, Aurora, CO USA;

<sup>2</sup>Emergency Medicine, Denver Health Medical Center, Denver, CO USA

**Objectives:** We developed an easily replicable, low-cost optic nerve sheath (ONS) phantom that simulates in vivo posterior ocular anatomy to facilitate ocular ultrasound training. The objective of this study was to validate an ocular phantom as a realistic educational tool utilizing in vivo and phantom ONS images obtained by ultrasound.

**Methods:** This prospective study enrolled 51 residents from the Denver Health residency in emergency medicine (EM) and 10 ultrasound fellowship-trained EM attendings. Subjects performed ONS diameter (ONSD) measurements on 5 in vivo and 5 phantom ocular ultrasound images and rated the reality of each image on a 5-point Likert scale. In vivo and phantom measurement precision was compared by estimating intraclass correlation coefficients (ICCs).  $\chi^2$  analysis was performed to evaluate the subjective “realness” of in vivo and phantom images.

**Results:** Sixty-one participants performed ONSD measurements. Mean Likert scale values were 3.43 (95% confidence interval [CI], 3.31–3.55) for in vivo images and 3.41 (95% CI, 3.28–3.54) for phantom images. There was no difference in subjective “realness” between in vivo and phantom ONSD ultrasound images among EM residents. Ultrasound fellowship-trained EM attendings aptly differentiated between in vivo ( $P < .01$ ) and phantom ( $P < .01$ ) images, as compared to EM residents (Table 1). Composite ICCs for in vivo and phantom images were 0.75 (95% CI, 0.59–0.91) and 0.85 (95% CI, 0.66–0.98), respectively, among all EM physicians.

**Conclusions:** Ultrasound operators exhibit similar inter-rater reliability among in vivo and phantom ONSD measurements. Our ocular phantom simulates in vivo posterior ocular anatomy. EM residents found the phantom indistinguishable from in vivo images. Our ONS phantom model provides an inexpensive and realistic educational tool to teach bedside ONSD sonography.

Table 1. Intraclass Correlation Coefficient of ONSD by Type of Eye

	ICC (95% CI)	
	In Vivo ONSD	Phantom ONSD
All physicians	0.75 (0.59–0.98)	0.85 (0.66–0.98)
Ultrasound fellowship trained	0.79 (0.53–0.97)	0.83 (0.59–0.98)
EM residents (postgraduate years 1–4)	0.61 (0.35–0.93)	0.85 (0.66–0.98)

### 2384790 Fetal Intracranial Magnetic Resonance Imaging in Complicated Monochorionic Multiple Gestations Undergoing In Utero Therapy

*Sherelle Laifer-Narin<sup>1,\*</sup>, Russell Miller<sup>2</sup>, Lynn Simpson<sup>2</sup>*

<sup>1</sup>Radiology, Columbia University Medical Center, New York, NY USA; <sup>2</sup>Obstetrics and Gynecology, Columbia University, New York, NY USA

**Objectives:** Monochorionic multiple gestations are at risk for specific complications as a result of uneven distribution of a common placenta or shared placental circulation, with examples including unequal placental sharing (UPS), twin-twin transfusion syndrome (TTTS), and single twin demise. Fetoscopic laser therapy and radiofrequency ablation (RFA) are procedures that are utilized for severe UPS and TTTS presentations, respectively. Fetal magnetic resonance imaging (MRI) has been utilized to assess for intracranial hemorrhage and/or ischemia in viable twins following these procedures.

**Methods:** This descriptive series is a retrospective study from April 2008 to August 2015 evaluating the utility of fetal MRI to detect intracranial hemorrhage and/or ischemia following laser or RFA therapy for complicated monochorionic gestations.

**Results:** A total of 70 cases were identified, including 37 post-laser and 33 post-RFA pregnancies. There was 1 set of monochorionic/diamniotic triplets in each group. The time interval range between the interventional procedure and fetal MRI was 3 days to 3 weeks. Gestational age at MRI ranged from 20 to 23 5/7 weeks. A single case of unilateral germinal matrix hemorrhage (1/33) was identified in the cohort of cases that underwent RFA. No abnormalities were seen in the remainder of RFA survivors. Thirty-seven monochorionic gestations were assessed in the post-laser MRI group, with 13 fetuses (12 twins/1 triplet) excluded due to in utero demise. Within the subgroup of single fetal demise, there was a single case of unilateral germinal matrix hemorrhage (1/13). In 12/13 cases with single fetal demise (11 twins, 2 triplets) there were no abnormal MRI findings. In 24 post-laser pregnancies without in utero demise, intracranial MRI was normal for 48 twins.

**Conclusions:** Fetal MRI demonstrated a low rate of neuroanatomic abnormalities in this cohort of fetuses who underwent in utero intervention for complications due to monochorionic status.

### 2373783 Sonographic Detection of Accessory Adrenal Tissue in Neonates

*Daniel Mordechay<sup>1,\*</sup>, Aviva Ben-Shlush<sup>1</sup>, Lisa Raviv-Zilka<sup>1,2</sup>, Jeffrey Jacobson<sup>1</sup>, Michelle Soudack<sup>1,2</sup>*

<sup>1</sup>Diagnostic Imaging, Chaim Sheba Medical Center at Tel Hashomer, Ramat Gan, Israel; <sup>2</sup>Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

**Objectives:** Accessory adrenal glands are developmental anomalies that occur when a small fragment breaks off from the parent adrenal gland during intrauterine life. Depending on what embryonic stage the fragmentation occurred, the fragment may be found at the gland's origin in the region of the celiac axis, embedded in the liver or kidney, in the suprarenal area, or it can migrate with the gonads as they descend into the pelvis or scrotum. The majority of accessory tissues are discovered incidentally during autopsy or surgery. There are numerous reports describing them in anatomic and surgical publications, in conjunction with adrenal tumors or cortical hyperplasia, or mimicking tumors in other organs. Our search of the English literature did not find any reports of accessory adrenal tissue detected sonographically near the parental gland. The objective of this presentation is to describe the incidence and appearance of accessory adrenal tissue in neonates, as diagnosed by high-resolution ultrasound, and increase the awareness of this entity.

**Methods:** We examined the adrenal glands in 153 neonates referred for renal and urinary tract ultrasound at our institution between January 2014 and January 2015. All kidneys and adrenal glands, except for

ectopic kidneys, were scanned with the infant prone and a linear array transducer with a frequency of 12 or 14 MHz.

**Results:** In 9 (5.8%) neonates, ultrasound identified a unilateral, small, well-defined round or slightly oval structure in the suprarenal area, measuring 2.9–4.5 mm and separate from the parent gland in all scan planes. In 1 neonate, the structure was slightly embedded into the upper pole of the right kidney. All structures had a hyperechoic center surrounded by a hypoechoic periphery, resembling the echogenicity of the normal neonatal adrenal, and were diagnosed as accessory adrenal tissue. On follow-up studies, available for 7 infants, these structures were not evident, and the suprarenal area was normal.

**Conclusions:** Accessory adrenal tissue can be identified in the suprarenal area in neonates with high-resolution ultrasound. Radiologists and sonographers caring for infants should be aware of this finding and not confuse it with pathology.

#### 2380220 The Hair Follicle Sign: An Ultrasound Finding to Help Make the Diagnosis of Pilomatricomas in Children

Anand Majmudar,\* Louis Parvey, Harris L. Cohen

Radiology, Lebonheur Children's Hospital, Memphis, TN USA

**Objectives:** To describe an additional sign that can help diagnose a pilomatricoma among the other subcutaneous masses.

**Methods:** Two cases diagnosed by ultrasound (US) and proven to be pilomatricomas using a high-frequency linear array transducer.

**Results:** A 7-year-old female with a right temple mass and a 6-year-old boy with a left eyebrow mass underwent US diagnosis. In both the cases, a linear echogenic hair follicle was noted to extend into the mass, which contained scattered calcification and had an echogenic border. This finding helped point to the suggested and proven diagnosis of pilomatricoma.

**Conclusions:** The hair follicle sign helps cement the diagnosis by US of pilomatricoma.

#### 2384900 Accuracy of Point-of-Care Lung Ultrasonography for Diagnosis of Acute Chest Syndrome in Pediatric Patients With Sickle Cell Disease and Fever

Dina Daswani<sup>1</sup>,\* Vaishali Shah<sup>1</sup>, Jeffrey Avner<sup>1</sup>, Deepa Manwani<sup>2</sup>, Jessica Kurian<sup>3</sup>, Joni Rabiner<sup>4</sup>

<sup>1</sup>Pediatrics, Division of Pediatric Emergency Medicine,

<sup>2</sup>Pediatrics, Division of Pediatric Hematology and Oncology,

<sup>3</sup>Radiology, Division of Pediatric Radiology, Children's Hospital

at Montefiore, Albert Einstein College of Medicine, Bronx, NY

USA; <sup>4</sup>Pediatric Emergency Medicine, Children's Hospital of New Jersey, Newark Beth Israel Medical Center, Newark, NJ USA

**Objectives:** To determine the test performance characteristics for point-of-care lung ultrasonography (LUS) performed by pediatric emergency medicine (PEM) physicians compared with radiographic diagnosis of acute chest syndrome (ACS) in patients with sickle cell disease (SCD) and fever.

**Methods:** This was a prospective study of patients up to 21 years with SCD and fever requiring chest x-ray (CXR) evaluation of ACS. Before obtaining CXR, a blinded PEM physician performed LUS using a standardized scanning protocol. Positive LUS for ACS was defined as lung consolidation. All patients received CXR and follow-up. The gold standard for ACS was consolidation on CXR as determined by a blinded radiologist. LUS clips were reviewed by a blinded expert PEM sonologist.

**Results:** One hundred sixteen febrile events from 91 patients with a mean age of 6.6 years were enrolled by 15 PEM sonologists. CXR was positive for ACS in 15 (13%) patients, and LUS was positive for ACS in 19 (16%) patients. Positive LUS had sensitivity of 87% (95% confidence interval [CI], 62%–96%), specificity of 94% (95% CI, 88%–97%), a positive likelihood ratio of 14.6 (95% CI, 6.5–32.5), and a negative likelihood ratio of 0.14 (95% CI, 0.04–0.52) for ACS. The interobserver agree-

ment ( $\kappa$ ) was 0.77. Use of LUS would reduce radiography in 84% of patients but would miss 2 cases of ACS.

**Conclusions:** LUS is highly sensitive and specific for diagnosis of ACS in pediatric patients with SCD and fever. LUS may reduce the need for routine CXR and associated ionizing radiation exposure in this population.

#### 2385835 Likelihood of Thyroid Cancer in Children

Hope Peters<sup>1</sup>,\* Danielle Richman<sup>1</sup>, Stephen Huang<sup>2</sup>, Peter Doubilet<sup>1</sup>, Carol Benson<sup>1</sup>, Mary Frates<sup>1</sup>

<sup>1</sup>Radiology, Brigham and Women's Hospital, Boston, MA USA;

<sup>2</sup>Endocrinology, Boston Children's Hospital, Boston, MA USA

**Objectives:** To determine the likelihood that a thyroid nodule in the pediatric population is malignant based on demographic and sonographic characteristics.

**Methods:** We identified all thyroid nodules with a maximum diameter of at least 10 mm in patients under 22 years of age undergoing ultrasound-guided fine-needle aspiration between January 2004 and October 2013. We recorded age and gender for each patient. For each nodule, we recorded size in 3 dimensions, location, composition (degree cystic vs solid), whether or not it was solitary (defined as no other nodule >5 mm in diameter), and pathologic diagnosis.

**Results:** We identified 180 nodules in 128 patients. Patient ages ranged from 2–21 years; 102 (79.7%) were female, and 26 (20.3%) were male. Multiple nodules were present in 48 (37.5%) patients, while a solitary nodule was identified in 80 (62.5%). Nodule location was closely divided between the right lobe (49.7%) and the left lobe (44.6%), with 5.6% located in the isthmus. Of 152 nodules with known pathology, 24 (15.8%) were malignant, and the majority of cancers were papillary (22 of 24 [91.7%]), including 3 diffuse sclerosing variant. Malignancy rates between sexes were similar (7/28 [25%] in boys and 17/110 [15.5%] in girls;  $P = .26$ , Fisher exact test). All malignant nodules were found in patients age 13 years or older ( $P = .07$ ). Nodules less than 50% cystic were more likely to be cancerous when compared to nodules greater than 50% cystic (22/101 [21.8%] vs 2/35 [5.7%],  $P = .02$ , Fisher exact test).

**Conclusions:** In the pediatric population with thyroid nodules at least 1 cm in maximum diameter, predominantly solid nodules are more likely to be malignant than predominantly cystic ones.

**SCIENTIFIC SESSIONS**  
**MONDAY, MARCH 21, 2016, 11:00 AM–12:30 PM**

**Contrast-Enhanced Ultrasound**

*Moderator: Andrej Lyshchik, MD, PhD*

**2385516 Quantitative Assessment of Tumor Perfusion During Sonoporation: Predicting Drug Uptake in Tumors**  
**Shashank Sirsi**

*Bioengineering, University of Texas, Dallas, TX USA*

**Objectives:** Over the last decade, microbubble contrast agents have frequently been cited as promising vehicles for targeted drug delivery applications. Microbubbles are gas-filled spheres between 1–10  $\mu\text{m}$  in diameter that circulate in the bloodstream when injected systemically. When insonified under specific ultrasound (US) conditions, microbubbles can alter vascular permeability by a technique called “sonoporation.” In this study, we develop a novel technique to simultaneously monitor tumor perfusion in 3D and apply sonoporation to enhance tumor drug delivery. We expect that this technique will be useful for predicting drug delivery efficacy in tumors using quantitative perfusion imaging techniques.

**Methods:** Matrigel plugs (BD Biosciences, Franklin Lakes, NJ) were used as mock tumors that promote neovascular growth when injected subcutaneously in CD-1 mice. The vasculature was allowed to grow for 10–14 days, and tumor perfusion was assessed using a Verasonics Vantage imaging scanner with a custom 3D probe. After perfusion imaging, Matrigel plugs were sonoporated using at 0–3  $\text{W}/\text{cm}^2$  (1 MHz, 10% duty cycle) for 10 minutes with a high dose of microbubbles ( $1 \times 10^9$  microbubbles) mixed with 5 mg of fluorescein isothiocyanate (FITC)-dextran (Sigma Aldrich, 3–5 kDa). Matrigel plugs were imaged again using US to monitor changes in perfusion and then excised to evaluate drug uptake by dissolving the plugs (Dispase; BD Biosciences) and quantifying FITC-dextran uptake.

**Results:** Matrigel sonoporation demonstrated significantly higher levels of FITC-dextran uptake with increasing US intensity. No significant differences in contrast volume were detected at any US intensity; however, contrast agent reflow rates were inversely correlated with FITC-dextran uptake.

**Conclusions:** Currently we are able to demonstrate significantly improved drug uptake in mock tumors using US-mediated sonoporation. In this study, we expect that quantitative 3D perfusion imaging could be used to predict levels of drug uptake in tumors, which would have a significant clinical impact for designing tailored drug treatment regimens for patients.

**2376902 A Novel Contrast-Enhanced Ultrasound Classification System for Solid and Cystic Renal Masses**

**Jessica Zarzour<sup>1</sup>, \* Janelle West<sup>2</sup>, Eric Turner<sup>2</sup>, Bradford Jackson<sup>2</sup>, Mark Lockhart<sup>1</sup>, Michelle Robbin<sup>1</sup>**

<sup>1</sup>Radiology, University of Alabama, Birmingham, AL USA;

<sup>2</sup>University of Alabama, Birmingham, AL USA

**Objectives:** To evaluate a new classification system in solid and cystic renal masses using contrast-enhanced ultrasound (CEUS).

**Methods:** This Institutional Review Board-approved retrospective study evaluated all patients who underwent CEUS from 2006–2015. Cystic renal lesions were classified according to the Bosniak computed tomographic (CT) classification and CEUS equivalent. Renal lesions were also classified utilizing a newly created system: class A, simple cysts, cysts with nonenhancing or minimally enhancing thin septation(s); class B, cystic lesions concerning for neoplasms (thick enhancing septation or nodular solid enhancing component); class C, solid enhancing neoplasms. The  $\kappa$  coefficient was calculated to determine inter-rater agree-

ment between Bosniak CT and CEUS classifications. Accuracy of CEUS was analyzed and compared with the histologic or follow-up final diagnosis.

**Results:** A total of 134 renal lesions were reviewed, with 108 lesions indeterminate by prior imaging. The mean lesion size was 2.9 cm (SD, 1.8). When comparing the Bosniak CT classification with the CEUS equivalent of the Bosniak classification system, the  $\kappa$  coefficient was 0.68 ( $P < .0001$ ). When comparing the Bosniak CT classification system with the new CEUS classification, the  $\kappa$  coefficient was 0.86 ( $P < .0001$ ), suggesting very high agreement. Of the 108 renal lesions indeterminate by prior imaging, 79.6% were given definitive diagnoses via CEUS evaluation (95% confidence limits, 0.71, 0.88;  $P < .0001$ ). Of the 24 lesions classified by CEUS as class B or C, 22 went on to pathologic diagnosis. Sensitivity was 100% ( $P < .0001$ ), positive predictive value was 0.91 ( $P < .0001$ ), and accuracy was 90.1% of the lesions with histology. Based on follow-up (mean, 339 days) and pathology, sensitivity was 100% ( $P < .0001$ ), specificity was 65% ( $P = .2$ ), positive predictive value was 0.74 ( $P = .01$ ), negative predictive value was 1.0 ( $P < .0001$ ), and accuracy was 82.6%.

**Conclusions:** This novel CEUS classification system and Bosniak classification system show good agreement. The CEUS classification system is highly sensitive for characterization of small renal masses.

**2360546 Two- and Three-Dimensional Contrast-Enhanced Ultrasound Monitoring of Renal Cell Carcinoma Recurrence After Cryoablation**

**John Eisenbrey<sup>1</sup>, \* Maria Stanczak<sup>1</sup>, Andrej Lyshchik<sup>1</sup>, Colette Shaw<sup>1</sup>, Ji-Bin Liu<sup>1</sup>, Costas Lallas<sup>2</sup>, Edouard Trabulsi<sup>2</sup>, Flemming Forsberg<sup>1</sup>**

<sup>1</sup>Radiology, <sup>2</sup>Urology, Thomas Jefferson University, Philadelphia, PA USA

**Objectives:** Following cryoablation of renal cell carcinoma (RCC), active surveillance using contrast-enhanced magnetic resonance imaging (MRI) or computed tomography (CT) may be limited by contrast media contraindications. This study investigated the use of 2D and 3D contrast-enhanced ultrasound (CEUS) to monitor RCC recurrence after cryoablation.

**Methods:** Patients scheduled for MRI or CT follow-up of a previously cryoablated RCC mass within the last 8 months to 3 years provided informed consent to undergo a CEUS exam. Imaging was performed using a GE LOGIQ E9 scanner with C1-5 and RAB2-5 probes (GE Healthcare, Milwaukee, WI). Following baseline imaging, patients received a 1-mL bolus injection of the ultrasound contrast agent Optison (GE Healthcare, Princeton, NJ) followed by a 10-mL saline flush during 2D imaging using the scanner's coded harmonic imaging package. After 10 minutes, the injection was repeated during continuous 3D imaging in coded harmonics mode. Enhancement patterns and kinetics from CEUS and the patient's clinically scheduled contrast-enhanced MRI or CT were then compared.

**Results:** Eight patients have enrolled in this ongoing study. Using MRI or CT as the patient's reference standard, no cases of RCC recurrence have been observed yet. Fat necrosis and areas of surrounding renal tissue scarring were observed in 2 and 3 patients, respectively. Renal ablation cavity sizes studied to date have ranged from 1.2 to 4.6 cm and volume acquisition rates from 0.8 to 2.0 volumes/second at depths up to 6 cm. On CEUS, a lack of enhancement within the treated mass was observed during the arterial and cortical enhancement phases for all cases. Late enhancement during the medullary phase was observed in masses later found as having fat necrosis or scarring on MRI or CT. While full volumetric data enabled complete visualization of the ablation cavity, it was found that differentiating vascular phases and the lesion border was more difficult due to motion artifacts and a lack of anatomic landmarks.

**Conclusions:** CEUS may be a useful alternative to monitoring RCC recurrence after cryoablation. Observed enhancement in the medullary phase appears consistent with fat necrosis and scar tissue findings on MRI and CT.



### 2363296 Impact of Race on Contrast-Enhanced Transrectal Ultrasound for Prostate Cancer Detection

Ethan Halpern<sup>1</sup>,\* Flemming Forsberg<sup>1</sup>, Leonard Gomella<sup>2</sup>, Edouard Trabulsi<sup>2</sup>

<sup>1</sup>Radiology; <sup>2</sup>Urology, Thomas Jefferson University, Philadelphia, PA USA

**Objectives:** Recent studies have demonstrated improved detection of larger-volume and higher-grade “clinically significant” prostate cancer (PCa) with contrast-enhanced ultrasound (CEUS)-guided targeted biopsy. As PCa tends to be a more aggressive disease among African American patients, this study evaluated the impact of a patient’s race on PCa detection rate with CEUS.

**Methods:** We reviewed demographic, ultrasound imaging, and pathologic results from 272 consecutive participants in a National Institutes of Health–funded clinical trial who underwent conventional 12-core systematic biopsy of the prostate as well as CEUS-guided targeted biopsy with up to 6 additional targeted biopsy cores. The microbubble agent Definity (Lantheus Medical Imaging) was used.

**Results:** The study population consisted of 210 Caucasian, 54 African American, 2 Asian, and 4 Hispanic males. PCa was detected in 87 (41%) of Caucasian and 29 (54%) of African American males. Among patients with a positive biopsy, PCa was present in multiple systematic cores in 41/87 (47%) Caucasian and 17/29 (59%) African American males, and high-grade PCa (Gleason score  $\geq 7$ ) was present in 30/87 (34%) Caucasian and 11/29 (38%) African American males. PCa was detected by systematic biopsy alone more frequently in African American (15/54 [28%]) as compared with Caucasian (30/210 [14%]) males. The frequency of high-grade PCa detected by systematic biopsy was similar in both populations (7/54 vs 27/210 [both 13%]). However, the frequency of high-grade PCa detected by targeted biopsy with CEUS was greater among our African American patients (9/54 [17%]) as compared with our Caucasian patients (21/210 [10%]).

**Conclusions:** The frequency of PCa, the number of positive biopsy cores among patients with PCa and the frequency of high-grade PCa were greater among our African American patients as compared with Caucasian patients. Although PCa was detected more frequently among our African American patients with conventional systematic biopsy, high-grade PCa in this population was detected more frequently with a limited targeted biopsy based on CEUS.

### 2363297 Optimal Combination of Contrast-Enhanced Targeted and Systematic Biopsy of the Prostate for Detection of High-Grade Prostate Cancer

Ethan Halpern<sup>1</sup>,\* Flemming Forsberg<sup>1</sup>, Leonard Gomella<sup>2</sup>, Edouard Trabulsi<sup>2</sup>

<sup>1</sup>Radiology; <sup>2</sup>Urology, Thomas Jefferson University, Philadelphia, PA USA

**Objectives:** The per-core detection rate for high-grade prostate cancer (PCa) is improved with contrast-enhanced transrectal ultrasound (CE-TRUS). Nonetheless, a limited targeted biopsy based on CE-TRUS may miss PCa that would be detected on a standard systematic biopsy. The purpose of the current study was to define an optimal biopsy strategy, combining systematic and targeted biopsy approaches to maximize by-patient detection of high-grade prostate cancer.

**Methods:** A total of 272 consecutive patients underwent CE-TRUS-targeted biopsy with up to 6 cores (mean: 4.5 cores/patient) during infusion of Definity (Lantheus Medical Imaging), followed by a 12-core systematic biopsy. The per-patient diagnosis of all PCa and high-grade PCa (Gleason score  $\geq 7$ ) was tabulated for 12-core systematic biopsy, for CE-TRUS-targeted biopsy, and for the combination of a laterally or medially directed sextant biopsy (6 cores) with CE-TRUS-targeted biopsy.

**Results:** PCa was identified in 276/3264 (8.5%) systematic cores and 203/1237 (16.4%) CE-TRUS-targeted cores ( $P < .001$ ). PCa

was detected more frequently per patient by systematic biopsy ( $n = 105$ ) as compared to CE-TRUS-targeted biopsy ( $n = 71$ ;  $P < .001$ ). Among 41 patients with high-grade PCa, high-grade PCa was detected slightly more frequently by systematic biopsy ( $n = 34$ ) relative to CE-TRUS-targeted biopsy ( $n = 30$ ;  $P = .48$ ). The combination of a medially or laterally directed sextant biopsy with CE-TRUS-targeted biopsy resulted in reduced overall per-patient detection of PCa ( $n = 90$  or  $91$ ) as compared with a systematic 12-core biopsy ( $n = 105$ ;  $P < .04$ ). However, the combination of a medially directed sextant biopsy with CE-TRUS-targeted biopsy (mean: 10.5 cores/patient) resulted in greater detection of high-grade PCa ( $n = 39$ ) as compared with a systematic 12-core biopsy ( $n = 34$ ;  $P = .18$ ).

**Conclusions:** Although a laterally directed sextant biopsy is most efficient for detection of PCa (Stamey TA. *Urology* 1995; 45:2–12), the optimal combination of systematic and CE-TRUS biopsy cores includes a medially directed sextant. This result is related to the superior efficacy of CE-TRUS for detection of laterally located PCa, which is not adjacent to the hypervascular transition zone.

### 2378454 Contrast-Enhanced Ultrasound for Differentiation of Small ( $\leq 2$ cm) Liver Metastases and Hepatocellular Carcinomas: Qualitative and Quantitative Evaluations

Wen-Ping Wang, Yi Dong,\* Feng Mao, Xiao-Long Zhang  
Ultrasound, Zhongshan Hospital, Fudan University, Shanghai, China

**Objectives:** To differentiate small ( $\leq 2$  cm) liver metastases and hepatocellular carcinoma (HCC) by evaluating qualitative and quantitative perfusion changes in contrast-enhanced ultrasound (CEUS).

**Methods:** In this retrospective study, qualitative and quantitative CEUS analyses were retrospectively performed in 120 cases of small liver metastases and 150 cases of small HCCs. CEUS was performed, and enhancement patterns of tumors were compared. Time-intensity curves were conducted with SonoLiver (TomTec Imaging Systems, Germany). Quantitative perfusion indices, such as rise time, time to peak (TTP), and tumor-to-cortex enhancement ratio were obtained and compared. Statistical analyses were performed using SPSS version 19.0 (SPSS Inc, Chicago, IL). The  $\chi^2$  test and the independent-sample  $t$  test were used to compare the qualitative and quantitative changes.

**Results:** Qualitative CEUS showed rapid rim enhancement in the arterial phase (65.8% in liver metastases vs 33.3% in HCCs;  $P < .01$ ), a hypoechoic appearance in the late arterial or early portal venous phase (95.8% in liver metastases vs 70.0% in HCCs;  $P < .05$ ), which were valuable characteristics for differentiating small ( $\leq 2$  cm) liver metastasis from HCCs. With quantitative analysis, TTP of small liver metastases ( $19.9 \pm 4.1$ ) was significantly shorter than small HCCs ( $23.0 \pm 5.6$ ;  $P < .05$ ).

**Conclusions:** Qualitative and quantitative CEUS analyses are helpful in the differential diagnosis of small liver metastases from small HCCs.

### 2380533 Role of Contrast-Enhanced Ultrasound in Assessment of Inflammatory Activity in Patients With Crohn’s Disease

Wenjie Cheng,\* Guangjian Liu

Ultrasound, Sixth Affiliated Hospital of Sun Yat-sen University, Guangzhou, Guangdong, China

**Objectives:** To evaluate the clinical value of quantitative contrast-enhanced ultrasound (CEUS) in assessing Crohn’s disease (CD) inflammatory activity compared with the power Doppler image and CEUS enhancement pattern.

**Methods:** We prospectively evaluated 55 patients with CD. Baseline US, power Doppler imaging (PDI), CEUS and quantitative analysis were performed. The pulsatility index (PI), rise time (RT), and time to peak (TTP) were obtained. High-sensitivity C-reactive protein (hs-CRP) was set as the reference standard. Data from active and inactive CD patients were compared using a  $t$  test and receiver operating characteris-

tic (ROC) analysis. Cutoff values were determined by ROC analysis, and sensitivity, specificity, accuracy, and Youden indices were calculated.

**Results:** There were 39 patients with active and 16 with inactive CD according to hs-CRP. According to Limberg classification using PDI, 35 of the patients were classified into active disease and showed sensitivity of 0.74, specificity of 0.75, accuracy of 0.75, and Youden index of 0.49. By using the enhancement patterns on CEUS, 44 of the patients were evaluated as inflammatory activity and showed a sensitivity of 0.87, specificity of 0.38, accuracy of 0.73, and Youden index of 0.25. Quantitative analysis showed a higher PI ( $>19$  dB), a shorter RT ( $\leq 6.2$  seconds), and a shorter TTP ( $\leq 8.7$  seconds) in patients with active inflammation than those from inactive CD patients ( $P < .05$ ). Youden indices were 0.56, 0.39, and 0.45. PI showed higher efficiency in assessing inflammatory activity of CD according to the comparison of the area under the ROC curve with enhancement patterns of CEUS ( $P < .05$ ). No significant differences were found between quantitative parameters (PI/RT/TTP) and PDI Limberg classification.

**Conclusions:** Quantitative analysis of CEUS provided better performance than CEUS enhancement patterns in assessment of the activity of CD. Although it is equal to the performance of PDI, it was more objective and should be recommended in clinical practice.

Table 1. Quantitative CEUS Enhancement Patterns

	Enhancement Pattern
I	Minimal enhancement
II	Submucosal enhancement
III	Transparietal outward enhancement
IV	Transparietal inward enhancement

### Fetal Echocardiography Moderator: Anita Moon-Grady, MD

#### 2362606 Fetal Myocardial Performance Index Can Predict Fetal Hypoxemia During Labor

Alexis Gimovsky,\* Dennis Wood, Stuart Weiner

Obstetrics and Gynecology, Division of Maternal-Fetal Medicine, Sidney Kimmel Medical College at Thomas Jefferson University Hospital, Philadelphia, PA USA

**Objectives:** The myocardial performance index (MPI) is a Doppler-derived myocardial function tool. The MPI is a noninvasive, easily attainable measure of cardiac function that can be obtained during labor and does not change with labor. The objective of the study was to investigate whether the left MPI can predict fetal hypoxemia in singleton pregnancies during labor.

**Methods:** Prospective cohort study of women with term singleton pregnancies in labor who were recruited at Thomas Jefferson University Hospital. Exclusion criteria were fetuses with known cardiac anomalies, multiple gestations, intrauterine growth restriction, and non-cephalic presentation. The primary outcome was sensitivity and specificity of left MPI for cord pH  $< 7.2$ . The secondary outcome was expedited delivery due to category 2 or category 3 fetal heart tracing. All participants underwent an ultrasound examination, during which the fetal left- and right-sided isovolumic contraction time (ICT), isovolumic relaxation time (IRT), and ejection time (ET) were recorded during labor. The left sided MPI was then calculated using the formula  $MPI = (ICT + IRT)/ET$ . A Student *t* test and  $\chi^2$  test were used as appropriate.  $P < .05$  was considered statistically significant. A receiver operating characteristic (ROC) curve was created to evaluate left MPI as a screening test.

**Results:** Twenty-four laboring patients were evaluated. Demographics and delivery outcomes were similar between groups. The ROC curve had an area under the curve of 0.692, with  $P = .258$ . For an MPI of  $\leq 0.51$ , there was sensitivity of 50.0% and specificity of 85.0% to predict cord pH  $< 7.20$ .

**Conclusions:** The MPI has a moderate ability to predict fetal hypoxemia during labor.

Table 1. Delivery Outcomes

	Total (n = 6)	MPI $\leq 0.51$ (n = 6)	MPI $> 0.51$ (n = 18)	P
Delivery type				.6
Spontaneous vaginal delivery	21 (87.5)	16 (88.9)	5 (87.5)	
Operative delivery	1 (4.2)	1 (5.6)	0 (0)	
Cesarean delivery	2 (8.3)	1 (5.6)	1 (16.7)	
Delivery for nonreassuring fetal heart tracing	1 (4.2)	0 (0)	1 (16.7)	.3
Birth weight, g	3204 (366)	3345 (574)	3150 (260)	.3

#### 2372011 HDliveFlow With HDlive Silhouette Mode/Glass Body Rendering Mode in the Assessment of the Fetal Heart

Mohamed AboEllail<sup>1,2,\*</sup>, Kenta Yamamoto<sup>1</sup>, Suraphan Sajapala<sup>1</sup>, Chiaki Tenkumo<sup>1</sup>, Megumi Ito<sup>1</sup>, Nobuhiro Mori<sup>1</sup>, Uiko Hanaoka<sup>1</sup>, Toshiyuki Hata<sup>1</sup>

<sup>1</sup>Perinatology and Gynecology, Kagawa University School of Medicine, Miki, Kagawa, Japan; <sup>2</sup>Gynecology and Obstetrics, Sohag University, Sohag, Egypt

**Objectives:** We present our experience with normal fetal cardiac structures and congenital heart disease (CHD) reconstructed using HDliveFlow with the HDlive silhouette mode/glass body rendering mode.

**Methods:** Ten normal fetuses and 8 fetuses with CHD (1 case each of tricuspid regurgitation [TR], ventricular septal defect [VSD], hypoplastic left heart syndrome [HLHS], Ebstein's anomaly, truncus arteriosus [TA], and right aortic arch [RAA] and 2 of double-outlet right ventricle [DORV]) at 11–35 weeks' gestation were included.

**Results:** In normal fetuses, origins of the pulmonary artery (PA) from the right ventricle (RV) and aorta (Ao) from the left ventricle (LV) were evident. Their courses and crisscross arrangements were clearly shown. The spatial 3-vessel view demonstrated their relation to the superior vena cava, and size comparison between them was easily achieved. The ascending Ao, aortic arch with its 3 main branches, and descending Ao were clearly visualized. The hepatic vein joining the inferior vena cava was also noted. Spatial impression of these great vessels and their relation to the spine was obvious using this technique. Mild TR was noted. In VSD, significant shunt flow through the VSD between left and right ventricles was evident. In HLHS at 16 weeks 4 days, a diminutive LV and significant TR with shunt flow across a large VSD were seen. A huge right atrium and small RV were seen in the case of Ebstein's anomaly. In TA, a single arterial trunk, straddling both ventricles and giving rise to the PA and Ao, was identified at 12 weeks 6 days. In RAA, a vascular ring around the trachea with clear visualization of the diverticulum of Kommerell and aberrant left subclavian artery was achieved at 34 weeks. In DORV, a large Ao and small PA leaving the RV in parallel were clearly shown.

**Conclusions:** This technique may assist in the evaluation of the fetal cardiovascular system in the normal heart and CHD, adjunctive to fetal echocardiography. HDliveFlow should become an important technology in future research on fetal cardiology.

### 2374880 Prenatal Diagnosis of Absent Pulmonary Valve Syndrome: Case Series of Five Cases; Most Common and Most Rare Presentations

**Alpana Joshi**

*Radiology, Shobha Diagnostic Center, Mumbai, Maharashtra, India*

**Objectives:** Absent pulmonary valve syndrome (APVS) is a rare congenital cardiac anomaly. Two variants of this anomaly are known. We report 5 patients who were referred to us for fetal echocardiography after abnormal findings on a detailed ultrasound scan. We discuss the fetal echocardiographic features of this rare cardiac anomaly.

**Methods:** We analyzed the fetal echocardiographic findings of APVS in 5 patients. The study was performed with Philips HD 11 XE and Philips iU22 ultrasound machines using a convex C5-2 transducer and fetal echo presets. The axis, size, and situs of the heart were evaluated. Color and spectral Doppler evaluation of both inflow and outflow tracts was done.

**Results:** The gestational age at diagnosis was 19–26 weeks. Of 5 cases, 4 cases showed typical features of APVS with a dilated pulmonary artery and its branches with a subaortic ventricular septal defect, overriding of the aorta, and ductal agenesis. There was typical to-and-fro flow noted on color and spectral Doppler examination. One fetus showed rare findings of APVS with an intact ventricular septum and patent ductus arteriosus associated with functional tricuspid atresia. We performed partial necropsy of the heart and lungs in this fetus with atypical features of APVS and confirmed these findings.

**Conclusions:** Antenatal diagnosis of the common variant (associated with tetralogy of Fallot) of APVS is easy due to its typical features of dilated main pulmonary and branch arteries and color Doppler detection of severe stenosis and insufficiency of the functionally absent pulmonary valve. However, the second variant of APVS can have varied findings, which can make a specific diagnosis difficult.

### 2381505 Impact of Congenital Heart Disease on In Utero Fetal Growth

**Mert Bahtiyar,\* Joshua Copel**

*Obstetrics and Gynecology, Yale University School of Medicine, New Haven, CT USA*

**Objectives:** The aim of this study was to compare fetal biometric measurements, estimated fetal weight, and frequency of intrauterine growth restriction (IUGR) between fetuses with congenital heart disease (CHD) and normal singleton fetuses.

**Methods:** This is a retrospective case-control study of patients who were referred for a fetal echocardiogram between January 1985 and December 2013 at a single academic center. During the study period, 11,083 fetal echocardiograms were performed on 9745 patients based on contemporary guidelines at the time. Fetuses with known other congenital abnormalities or chromosomal anomalies were excluded, leaving 10,463 fetal echocardiographic examinations that were included in this study. The control group was constituted of randomly selected 25,000 singleton gestations without any known or suspected fetal anomaly seen on ultrasound examination during the same study period. Fetal growth restriction was defined as estimated fetal weight below the 10th percentile for the gestational age.

**Results:** During the study period, 875 fetuses were prenatally diagnosed with CHD of varying severity. Overall, the prevalence of any CHD was 8.4%. The prevalence of IUGR was significantly higher in fetuses with CHD compared to fetuses without any anomalies: 20.0% and 9.1%, respectively ( $P < .05$ ). On multivariate analysis, there was no statistically significant difference in fetal growth between study and control groups at 16–28 weeks of gestation. However, after 28 weeks of gestation, fetal growth was significantly lagging in fetuses with CHD ( $P < .05$ ). Similarly, abdominal circumference measurements were significantly lag-

ging after 28 weeks of gestation ( $P < .05$ ). There was no difference in biparietal diameter throughout the pregnancy.

**Conclusions:** Consistent with previously published literature, we confirmed that fetuses with CHD are likely to have growth restriction, which is more pronounced in the third trimester. Fetuses with CHD should be followed closely for fetal growth restriction.

### 2383980 The Role of the 3-Vessel and Trachea View in Antenatal Detection of Tetralogy of Fallot

**Anna Palatnik<sup>1</sup>,\* William Grobman<sup>1</sup>, Leiber Cohen<sup>1</sup>, Jeffrey Dungan<sup>1</sup>, Nina Gotteiner<sup>2</sup>**

*<sup>1</sup>Obstetrics and Gynecology, Northwestern University, Feinberg School of Medicine, Chicago, IL USA; <sup>2</sup>Pediatrics, Northwestern University, Chicago, IL USA*

**Objectives:** Prenatal diagnosis of tetralogy of Fallot (TOF) remains less frequent compared to other major congenital heart defects. The aim of this study was to examine how often the 3-vessel and trachea view was abnormal in a large series of prenatally diagnosed TOF and to compare its sensitivity to that of the traditional outflow tract views.

**Methods:** This was a case series with retrospective analysis of all antenatally diagnosed TOF fetuses with postnatal confirmation at a single tertiary care institution between April 2007 and May 2015. Only cases of TOF diagnosed between 18 and 24 weeks were considered with regard to determination of the frequency of prenatal detection. Measurements of the aortic annulus (AA) and main pulmonary artery annulus (MPA) were obtained at the outflow tract views, and measurements of the aortic arch isthmus (AAi) and ductus arteriosus (DA) were obtained at the 3-vessel and trachea view. Z scores were calculated for all 4 dimensions according to Schneider's nomograms. In order to determine which measures were most sensitive in the detection of TOF, the frequencies of Z scores  $\geq 2.0$  were compared for all 4 measurements using McNemar's test.

**Results:** During the study time period, 40 fetuses were diagnosed with TOF. There were 2 additional cases of newborns delivered at our institution with postnatal diagnosis of TOF who had received a routine sonographic survey that did not detect TOF, thus accruing to a 95% (40/42) prenatal detection rate (95% confidence interval, 88%–99%). In all cases, the AA/MPA and AAi/DA ratios were  $>1$  in the outflow tract and 3-vessel and trachea views, respectively. As a single measurement, when using the Z score value of 2, the AAi measurement obtained at the 3-vessel and trachea view was found to be more frequently abnormal than the AA or MPA measurement obtained at the outflow tract view (86.5% vs 42.5%;  $P = .002$  for AA; and 86.5% vs 65.0%;  $P = .003$  for MPA).

**Conclusions:** Both the outflow tract and the 3-vessel and trachea views were abnormal in all fetuses with TOF, demonstrating reversed AA/MPA and AAi/DA ratios, respectively. However, as a single measured marker, the enlarged AAi on the 3-vessel and trachea view appears to be the most sensitive for TOF.

### 2384593 Retrospective Versus Prospective Normograms for the Cardiac Axis at 11 to 14 Weeks in a Lebanese Population: Is There a Difference?

**Reem Abu-Rustum<sup>1</sup>,\* M. Fouad Ziade<sup>2</sup>, Sameer Abu-Rustum<sup>3</sup>**

*<sup>1</sup>Center for Advanced Fetal Care, Tripoli, Lebanon; <sup>2</sup>Faculty of Public Health, Lebanese University, Tripoli, Lebanon; <sup>3</sup>Obstetrics and Gynecology, Nini Hospital, Tripoli, Lebanon*

**Objectives:** To evaluate the feasibility of measuring the cardiac axis (CAX) at 11–14 weeks and to compare our normograms to that established by Sinkovskaya et al.

**Methods:** The study was initially carried out retrospectively. On data analysis, it was repeated prospectively. In both instances, 100 normal fetuses had a full anatomic survey at the time of nuchal translucency (NT) assessment by a single sonologist certified by the Fetal Medicine Foundation. Maternal body mass index (BMI), crown-rump length (CRL),



and NT were obtained. The CAx was measured at the level of the 4-chamber view. In the retrospective group, the optimal stored image, with or without color Doppler, was utilized. In the prospective group, the CAx was measured utilizing high-definition flow (HDF) with optimal filling of the chambers. Neonatal outcome was available on the retrospective fetuses. The Kolmogorov-Smirnov test was used to assess normality. Data were analyzed using means (SD) and ranges. The effect of CRL on the CAx was evaluated using regression analysis. A *t* test was used to compare our means to the established means.  $P < .05$  was considered significant.

**Results:** The CAx was measured on all fetuses in both cohorts. The patient characteristics were similar in both retrospective and prospective cohorts, with a mean maternal BMI of 25.06 vs 25.42, CRL of 69.39 vs 68.43 mm, and NT of 1.75 vs 1.82 mm, respectively. CAx was found to be normally distributed in both with no significant effect of CRL on CAx ( $P = .675$  and  $.656$ , respectively). However, comparing the mean CAx, it was  $46.7^\circ$  retrospectively and was statistically different from Sinkovskaya et al, with  $P = .034$ . Prospectively, the mean CAx was  $45.98^\circ$ , and it was not statistically different from what has been established, with  $P = .302$ . Of note is that in the retrospective group, the range was  $27.30^\circ$ – $83.93^\circ$  vs  $26.88^\circ$ – $60.95^\circ$  in the prospective group.

**Conclusions:** It is feasible to obtain the CAx at 11–14 weeks. There is a significant difference between our retrospective and prospective data particularly in the upper limits of normal. This may be attributed to utilizing HDF. As such, it may be a consideration to employ HDF to enhance accuracy when introducing this powerful new marker into routine first-trimester screening.

#### 2384602 Are There Head Volume Alterations at 11 to 14 Weeks in Fetuses With Congenital Heart Defects?

Reem Abu-Rustum<sup>1</sup>, \*M. Fouad Ziade<sup>2</sup>, Sameer Abu-Rustum<sup>3</sup>, Linda Daou<sup>4</sup>

<sup>1</sup>Center for Advanced Fetal Care, Tripoli, Lebanon; <sup>2</sup>Faculty of Public Health, Lebanese University, Tripoli, Lebanon; <sup>3</sup>Obstetrics and Gynecology, Nini Hospital, Tripoli, Lebanon; <sup>4</sup>Pediatric Cardiology, St Joseph University, Beirut, Lebanon

**Objectives:** To assess the presence of head volume (HV) alterations at 11–14 weeks in fetuses with congenital heart defects (CHDs).

**Methods:** Retrospective case-control study on 100 controls and 26 fetuses with CHDs. All fetuses had a first-trimester scan with nuchal translucency, crown-rump length (CRL), and cardiac axis measured, and volume data sets were stored. All scans and volume analyses were carried out by a single sonologist certified by the Fetal Medicine Foundation. From the 3D volumes, the plane of the biparietal diameter was reconstructed using rotation along the 3 axes. Virtual organ computer-aided analysis was activated using a manual trace at a rotational angle of  $30^\circ$  to calculate the HV. Fetuses with suboptimal volumes due to motion artifacts and shadowing were excluded from the analysis. All controls had a second-trimester scan and a normal neonatal exam. The presence of extracardiac anomalies and aneuploidy in fetuses with CHDs was recorded. Live-born fetuses with CHDs were evaluated by a pediatric cardiologist. The HV as a function of CRL in fetuses with CHDs (grouped as hypoplastic left heart [HLH] and other) was plotted against the normals. The Nonparametric Kruskal-Wallis H test was used for comparing the measurements.  $P < .05$  was considered significant.

**Results:** Included in the analysis were 102 fetuses: 83 normals and 19 with CHDs. Of the CHD fetuses, there were 7/19 (36.8%) with HLH, 6/19 (31.2%) with a ventricular septal defect/atrioventricular canal, 3/19 (15.8%) with hypoplastic right heart, 2/19 (10.5%) with isomerism, and 1/19 (5.3%) with tetralogy of Fallot. Karyotype was available on 4/19 (21%); 2 were trisomy 21. Extracardiac abnormalities (excluding hydrops) were present in 9/19 (47.4%). Of the 19 fetuses, 2 were live born (10.5%). Termination of pregnancy was carried out on 13/19 (68.4%). There was

spontaneous in utero demise in 2/19 (10.5%). In addition, 2/19 (10.5%) were lost to follow-up. The HV as a function of the CRL revealed a significant difference between fetuses with CHDs and normals, with a statistically smaller HV in fetuses with CHDs. This was particularly applicable to fetuses with HLH ( $P = .043$ ).

**Conclusions:** Despite the small sample size, our data suggest that the brain-sparing effect, as evidenced by alterations in HV, may be apparent as early as the first trimester in fetuses with CHDs and, in particular, those with HLH. Larger prospective studies are needed to validate our findings.

#### 2384728 Two-Dimensional Speckle Tracking of the Longitudinal Systolic Displacement of the Right and Left Ventricular Chambers: Does It Alter the Interpretation of Fetal M-Mode Echocardiography?

Greggory DeVore<sup>1,2</sup>, \*Bardo Polanco<sup>1</sup>, Gary Satou<sup>3</sup>, Mark Sklansky<sup>3</sup>

<sup>1</sup>Fetal Diagnostic Center, Pasadena, CA USA; <sup>2</sup>Obstetrics and Gynecology; <sup>3</sup>Pediatric Cardiology, David Geffen School of Medicine at UCLA, Los Angeles, CA USA

**Objectives:** From the 2D 4-chamber view (4CV) the longitudinal systolic displacement (LSD) was measured with 2D speckle tracking obtained from the endocardium of the right ventricular (RV) and left ventricular (LV) lateral and septal walls. LSD was correlated with simultaneously recorded M-mode tracings obtained perpendicular to the interventricular septum at the basal (B), mid (M), and apical (A) levels from the 4CV.

**Methods:** The 4CV was recorded from 200 fetuses between 19 and 40 weeks of gestation in which the LSD from the endocardial B, M, and A of the lateral and septal walls of the RV and LV was measured. The displacements of the B, M, and A segments for each ventricle were summed, and the percentage of displacement computed for each segment was analyzed using repeated analysis of variance. In a subgroup of fetuses, the 4CV and a simultaneous M-mode were recorded at the B, M, and A regions of the RV and LV.

**Results:** The percent of LSD was not correlated with gestational age. There was a significant decrease in the percent of LSD from the base to the apex of the RV and LV (Table 1). When the simultaneous M-mode was analyzed, the end-systolic M-mode represented a different portion of the ventricular and septal endocardium than the diastolic M-mode because of LSD of the B, M, and A segments.

**Conclusions:** When the M-mode is used to measure diastolic and systolic dimensions of the ventricular chambers, the cursor should be placed in the midportion of the ventricular chamber to minimize measurement errors resulting from LSD.

Table 1. Percent of LSD for the B, M, and A Sections for the LV and RV Lateral Walls (LVLW and RVLW) and LV and RV Septal Walls (RVSW and LVSW)

Section	LVLW	LVSW	RVLW	RVSW
B	43.1% (SE = 0.055%)	48.4% (SE = 0.74%)	43.8% (SE = 0.43%)	46.6% (SE = 0.54%)
M	34.4% (SE = 0.55%)	32.8% (SE = 0.74%)	34.2% (SE = 0.43%)	32.6% (SE = 0.54%)
A	22.5% (SE = 0.49%)	18.7% (SE = 0.59%)	22.1% (SE = 0.40%)	20.7% (SE = 0.54%)
B vs M	$P < .001$	$P < .001$	$P < .001$	$P < .001$
M vs A	$P < .001$	$P < .001$	$P < .001$	$P < .001$
B vs A	$P < .001$	$P < .001$	$P < .001$	$P < .001$

**2384999 Semiautomated Evaluation of the Fetal Heart Using a 5DHeart Approach: Recent Data on Validity and Reproducibility in First- and Second-Trimester Fetuses**  
**Jan Weichert,\* Michael Gembicki, David Hartge**  
*Obstetrics and Gynecology, Prenatal Medicine, University Hospital of Schleswig-Holstein, Campus Luebeck, Luebeck, Germany*

**Objectives:** To scrutinize the performance and reliability of 5DHeart technology for standardized assessment of the fetal heart in first- and second-trimester pregnancies.

**Methods:** In this prospective study, we enrolled 114 uncomplicated singleton pregnancies undergoing targeted first- and second-trimester ultrasound examination including spatiotemporal image correlation (STIC) volumes of the fetal heart. All volume data sets were obtained with the fetus in an appropriate position (spine located between 5 and 7 o'clock), absent or minimal fetal breathing/movement, and satisfying image quality. All data sets were stored and reevaluated using FINE (Fetal Intelligent Navigation Echocardiography) software in order to rule out the visualization rates of 9 reconstructed cardiac planes.

**Results:** A total of 103 patients were eligible for final analysis. The mean gestational age (GA) was 18.4 weeks (ranging from 11.3–26.0 weeks). One to 4 STIC volumes were obtained per patient (mean, 1.4 exams). In 85% of all volumes, 6 or more planes were sufficiently visualized, and in 61/103 cases, all planes were adequately displayed and labeled, or not more than 1 diagnostic plane failed. Although the rate of nonvisualized planes increased with decreasing GA, we were able to reconstruct 6 or more planes in 61% of all first-trimester volumes (>95% in second trimester). Those planes that were difficult to obtain merely comprised the ductal and aortic arch in our cohort (regardless of the GA).

**Conclusions:** 5DHeart technology facilitates reliable assessment of fetal cardiac anatomy even when used as early as the first trimester. With ongoing pregnancy, the visualization rate of all diagnostic planes needed during fetal echocardiography improves rapidly.

**2385824 Evaluation of Transverse Systolic Displacement of the Endocardium of the Right and Left Ventricles of the Fetal Heart Using Two-Dimensional Speckle Tracking**  
**Greggory DeVore<sup>1,2</sup>,\* Bardo Polanco<sup>1</sup>, Gary Satou<sup>3</sup>, Mark Sklansky<sup>3</sup>**

*<sup>1</sup>Fetal Diagnostic Center, Pasadena, CA USA; <sup>2</sup>Obstetrics and Gynecology, <sup>3</sup>Pediatric Cardiology, David Geffen School of Medicine at UCLA, Los Angeles, CA USA*

**Objectives:** Evaluate the transverse systolic displacement (TSD) of the endocardium toward the center of the ventricular chamber from the basal (B), mid (M), and apical (A) segments of the septal and lateral walls for the right ventricle (RV) and left ventricle (LV).

**Methods:** The 4-chamber view was recorded from 200 fetuses between 19 and 40 weeks of gestation. The TSD represents the distance the endocardium moves transversely from point A (end diastole) to point B (end systole) toward the center of the ventricular chamber. From this analysis using 2D speckle tracking, the TSD of the endocardial B, M, and A segments from the lateral and septal walls of the RV and LV was measured. The TSD for the B, M, and A segments was summed and the percentage [eg, 100 \* (B/B + M + A)] each segment contributed was analyzed using repeated analysis of variance. Comparison of the B, M, and A septal and lateral wall segments was performed for each chamber, as well as a comparison between the RV and LV septal segments and the RV and LV lateral segments (Table 1).

**Results:** TSD of the B, M, and A segments was greater for the lateral than the septal wall for both chambers (Table 1). The LV septal segments had greater displacement than the RV septal segments (Table 1). Except for the basal segment of the RV, the LV lateral wall segments had a higher displacement than the RV lateral wall (Table 1).

**Conclusions:** In the fetal heart, the lateral ventricular segments have a greater TSD than their respective septal segments. The LV septal segments have greater TSD toward the LV chamber than the RV septal segments do toward the RV chamber. Except for the B segment, the M and A LV segments have greater TSD than their corresponding RV counterparts. Understanding the foregoing relationships will allow the clinician to evaluate TSD in various fetal diseases to see how they may alter cardiac function.

Table 1. Summary of the Results

	RV Septum vs RV Lateral Wall	LV Septum vs LV Lateral Wall	RV Septum vs LV Septum	RV Lateral Wall vs LV Lateral Wall
B segment	43% vs 86% <sup>a</sup>	22% vs 78% <sup>a</sup>	41% vs 59% <sup>a</sup>	53% vs 47% <sup>a</sup>
M segment	12% vs 88% <sup>a</sup>	38% vs 62% <sup>a</sup>	18% vs 82% <sup>a</sup>	49% vs 51% <sup>a</sup>
A segment	13% vs 87% <sup>a</sup>	51% vs 48% <sup>a</sup>	9% vs 91% <sup>a</sup>	41% vs 59% <sup>a</sup>

<sup>a</sup>*P* < .01.

## Obstetric Ultrasound: Fetal Growth

*Moderator: Wesley Lee, MD*

**2361852 The Femur Length/Abdominal Circumference Ratio for Prediction of Shoulder Dystocia and Neonatal Brachial Plexus Palsy in Women With Gestational Diabetes**  
**Elaine Duryea<sup>1</sup>,\* Donald McIntire<sup>1</sup>, Brian Casey<sup>1</sup>, Diane Twickler<sup>2</sup>**

*<sup>1</sup>Obstetrics, <sup>2</sup>Radiology, University of Texas Southwestern Medical Center, Dallas, TX USA*

**Objectives:** To determine whether the femur length-to-abdominal circumference ratio (FL/AC) may be useful in the identification of women with gestational diabetes mellitus (GDM) at increased risk of shoulder dystocia and neonatal brachial plexus palsy (NBPP).

**Methods:** This was a retrospective cohort study of women with GDM who delivered singleton live-born infants at our institution from 1997 to 2015. Diagnosis and treatment of GDM was uniform during the study period, including routine sonography after 32 weeks' gestation. Various measurements and calculations such as biparietal diameter, FL, AC, and FL/AC, as well as estimated fetal weight and AC percentiles were evaluated for correlation with shoulder dystocia and NBPP in comparison to birth weight (BW).

**Results:** During the study period, 6952 women with GDM underwent a sonogram at 34.8 ± 1.8 weeks' gestation; 2768 (40%) underwent cesarean delivery, with 4 cases of NBPP (1.5/1000); 4183 women underwent vaginal delivery, with 66 cases of shoulder dystocia (16/1000) and 13 NBPP (6/1000). FL/AC was most closely associated with shoulder dystocia (*P* < .001) with an area under the curve of 0.70 (confidence interval, 0.64–0.77), which was not improved with the addition of other ultrasound parameters to the prediction model. A FL/AC of <0.2 yielded a sensitivity of 29% for shoulder dystocia and 15% for NBPP, similar to the retrospective use of BW >4500 g (Table 1). When examining the FL/AC in 281 women with multiple sonograms after 32 weeks' gestation, the ratio was stable with advancing gestational age (*P* = .96).

**Conclusions:** In women with GDM, the FL/AC in the third trimester is a simple, stable measurement that may assist in identification of women with GDM at increased risk for shoulder dystocia and NBPP.

Table 1.

	Sensitivity	Specificity	PPV	NPV	False+ Rate
Shoulder dystocia					
BW >4500 g	27.3%	98.5%	22.2%	98.8%	4.6%
FL/AC <0.19	6.1%	98.6%	6.7%	98.5%	1.4%
FL/AC <0.2	28.8%	91.2%	5.0%	98.8%	8.8%
NBPP					
BW > 4500 g	19.2%	98.2%	6.2%	99.5%	1.8%
FL/AC <0.19	7.7%	98.6%	3.3%	99.4%	1.4%
FL/AC <0.2	15.4%	91.0%	1.1%	99.4%	9.0%

Twenty cesareans would be required to prevent 1 shoulder dystocia and 100 to prevent 1 NBPP if the decision were made using FL/AC <0.2 alone. NPV indicates negative predictive value; and PPV, positive predictive value.

### 2371462 The Influence of Cardiac Defects, Anomalies, and Soft Markers on the Growth Pattern of Fetuses With Trisomy 21

Timothy Canavan<sup>1</sup>, \* Sarah Bernstein<sup>2</sup>, Devereux Saller<sup>1</sup>

<sup>1</sup>Obstetrics, Gynecology, and Reproductive Sciences, University of Pittsburgh—Magee Women's Hospital, Pittsburgh, PA USA;

<sup>2</sup>Obstetrics and Gynecology, Massachusetts General Hospital, Boston, MA USA

**Objectives:** Fetuses with trisomy 21 are noted to have varying growth patterns from normal to significant growth restriction. The purpose of this study is to determine if a congenital heart defect (CHD), any congenital anomaly (A), a trisomy 21 soft marker (SM), any combination of these findings is associated with different growth patterns in fetuses with trisomy 21.

**Methods:** This is a retrospective study of 425 ultrasound exams in 235 patients with trisomy 21, identified by antenatal or neonatal karyotype, comparing the fetal growth pattern with the presence of a CHD, A, or SM (echogenic intracardiac focus, echogenic bowel, thickened nuchal fold, pyelectasis, or shortened femur or humerus; Table 1). Using hierarchical linear modeling, fetal growth was defined using the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur diaphysis length (FDL) and then compared to the presence of CHD, A, SM, or any combination.  $P < .05$  was considered significant.

**Results:** The BPD, HC, AC, and FDL were all statistically significant for the prediction of the fetal size compared to the gestational age (all  $P < 0.001$ , except HC, which ranged from .008 to .021). The presence of a CHD, A, SM, or any combination (any finding) was not associated with a statistically significant difference in the linear regression–defined fetal growth equation.

**Conclusions:** The fetal growth pattern in trisomy 21 is not statistically influenced by the presence of a CHD, A, or SM.

Table 1. Subject Distribution in Test Groups<sup>a</sup>

	n (%)
CHD	39 (16.6)
A	54 (23.0)
SM	51 (21.7)
Any finding	93 (39.6)

<sup>a</sup>Subjects may be represented in multiple groups.

### 2380580 Does the Timing of the Appearance of the Fetal Proximal Humeral Epiphysis Differ Between Ethnic Groups?

Deepika Garg, \* Scarlett Karakash, Tinu Hirachan, Shoshana Haberman

Obstetrics and Gynecology, Maimonides Medical Center, Brooklyn, NY USA

**Objectives:** Accurate determination of the expected date of delivery is critical since clinical management is often determined by gestational age. Previous studies have suggested that the appearance of the ossification center in the proximal humeral epiphysis (PHE) may be a reliable indicator of term gestation and appears around 38 weeks of gestation. Our aim was to determine if the sonographic appearance of the fetal PHE correlates with gestational age and is consistent among various ethnic groups.

**Methods:** A prospective observational study of 563 patients between August 2013 and June 2015. Inclusion criteria: singleton pregnancies at >34 weeks of gestation, well dated by first-trimester sonogram. Pregnancies with skeletal dysplasia, congenital malformation, or unclear dating were excluded.

**Results:** The PHE was not seen in any patients at 34 and 35 weeks and was present in only 2.2% of patients at 36 weeks across different ethnic groups. The appearance of the PHE in the full cohort at gestational ages of 37, 38, 39, and 40 weeks was 11.9%, 51%, 75%, and 100% respectively (Table 1). No significant differences between ethnic groups were noted in the appearance of the PHE.

**Conclusions:** We found a relatively high prevalence of the PHE in women at 39 weeks or above with no differences between ethnic groups. This suggests that the appearance of the PHE can be used as a reliable indicator of term gestation independent of ethnic group and may be useful for patients with poor dating who present for care in the late third trimester.

Table 1. Appearance of PHE by Gestational Age

Gestational Age, wk	PHE Present	PHE Absent	Total	% Presence of PHE
34	0	44	44	0
35	0	36	36	0
36	3	130	133	2.20
37	15	111	126	11.90
38	49	47	96	51.04
39	75	25	100	75
40	28	0	28	100
Total	170	393	563	

### 2380747 Pathologic Fetal Growth: How Does Intergrowth 21 Compare With Established Growth Curves?

Nicole Smith, \* David Cantonwine, Julian Robinson

Obstetrics and Gynecology, Brigham and Women's Hospital, Boston, MA USA

**Objectives:** Fetal growth restriction is a strong risk factor for stillbirth. We compared the performance of the newly published Intergrowth 21 (IG21) fetal growth norms against established ultrasound (US)- and birth weight (BW)-based curves in identifying abnormally grown fetuses.

**Methods:** We previously performed a case-control study of singleton stillbirths (2000–2010) at 1 center. Four live-born controls were randomly identified for each stillbirth. Fetal growth measurements taken within 1 month of delivery were used to calculate growth percentiles for each fetus. Abdominal circumference (AC) alone has been shown to predict both small for gestational age (SGA) and large for gestational age (LGA). IG21 describes percentiles for individual measurements rather



than estimated fetal weight; thus, in this secondary analysis, IG21 and Hadlock curves (Had AC) were applied to AC measurements for cases and controls. These findings were compared to fetal weight percentile by 2 fetal weight growth norms: the Hadlock US-based curve and a BW-based curve. Odds of being defined as <3rd, 3rd–10th, and >90th percentiles were calculated. The likelihood of being defined as SGA (<10th) or LGA (>90th) was examined with McNemar's test.

**Results:** There were 49 stillbirths and 197 live births. Odds of stillbirth among fetuses identified as SGA <3rd percentile when IG21 was applied were 15.5 (3.0, 78.7), as compared to 1.65 (0.68, 4.01) under Had AC. Applying a BW or US curve, the odds ratio was 10.4 (1.94, 55.7) or 6.0 (2.0, 17.9). The likelihood of SGA or LGA was significantly different in both stillborns and live borns, depending on the growth curve used. Growth was significantly more likely to be called abnormal (<10th or >90th percentile) with IG21 as opposed to US or BW curves ( $P < .0001$ ), largely due to significantly more LGA (31%;  $P < .0001$ ). Significantly fewer fetuses in either group were SGA by IG21 than by Hadlock or Had AC ( $P < .0001$ ;  $P = .002$ ).

**Conclusions:** The IG21 fetal growth curve performed differently than either US- or BW-based norms. Similar to the BW curve, IG21 identified fewer fetuses as SGA than did US based curves. Odds of stillbirth were highest when IG21 identified growth as <3rd percentile. IG21 also identified the greatest proportion of stillborn and live-born fetuses as LGA.

#### 2382783 Sonographic Detection of Birth Weight at or Below the Third Percentile in Women With Treated Chronic Hypertension

**Jamie Morgan,\* Chet Wells, Donald McIntire, David Nelson**  
*Obstetrics and Gynecology, University of Texas Southwestern Medical Center, Dallas, TX USA*

**Objectives:** To assess the utility of antenatal sonography to identify severe infant growth restriction, defined as birth weight at or below the 3rd percentile, in a cohort of high-risk women with treated chronic hypertension (CHTN) during pregnancy.

**Methods:** This was a retrospective cohort study of singleton pregnancies delivered at our hospital. All women were diagnosed with chronic hypertension and required antihypertensive therapy during pregnancy and routinely received sonograms to assess fetal growth at 2 epochs: (1) 26–28 weeks and (2) 34–36 weeks. The infant birth weight percentile was determined using a gestational age-specific nomogram derived from births at our institution. For this study, sonographic assessment of estimated fetal weight (EFW) at or below the 10th percentile using the Hadlock nomogram and biometric indices was compared with subsequent birth weights at or below the 3rd percentile to evaluate the utility of sonography to detect or exclude severe infant growth restriction at separate gestational age epochs as well as in paired observations for those with serial sonograms.

**Results:** Between January 2002 and December 2014, a total of 189 women with treated CHTN underwent a third-trimester sonogram at 34–36 weeks, and 16 (8%) delivered an infant weighing at or below the 3rd percentile. Despite diminished sensitivity, the utility of the sonogram to reliably exclude severe growth restriction was excellent, with a negative predictive value of 98%. Using receiver operator curves to compare sonograms performed at 26–28 weeks as well as biometric indices, EFW measured at 34–36 weeks was the most powerful sonographic predictor of subsequent severe fetal growth restriction (area under the curve, 0.87; 95% confidence interval, 0.79, 0.95). Findings for EFW at 34–36 weeks were significant against all other features ( $P < .01$  for all comparisons at 34–36 weeks).

**Conclusions:** Women with CHTN requiring treatment during pregnancy are at a nearly 3-fold increased risk for delivery of an infant weighing at or below the 3rd percentile. In this highly susceptible cohort of women, the utility of the commonly used Hadlock equation to exclude a severely growth-restricted infant appears to be most effective later in gestation at 34–36 weeks.

#### 2385863 Does Asymmetric Fetal Growth Exist in Women With Treated Chronic Hypertension?

**Jamie Morgan,\* Chet Wells, Donald McIntire, David Nelson**  
*Obstetrics and Gynecology, University of Texas Southwestern Medical Center, Dallas, TX USA*

**Objectives:** To assess the discordance of biometric parameters in severely growth-restricted infants weighing below the 3rd percentile at birth using the head circumference-to-abdominal circumference ratio (HC/AC) as a measure of asymmetric fetal growth in women with treated chronic hypertension (CHTN).

**Methods:** This was a retrospective cohort study of singleton pregnancies delivered at our hospital between January 2002 and December 2014. All women were diagnosed with chronic hypertension and required antihypertensive therapy during pregnancy. These women were cared for in a specialized prenatal clinic and received sonograms to measure fetal growth during the second half of pregnancy. Fetal weight was calculated according to the Hadlock formula using routinely assessed biometric parameters. The infant birth weight percentile was determined using a gestational age-specific nomogram derived from births at our institution. A gestational-age specific HC/AC nomogram was derived for infants with birth weights between the 25th and 75th percentiles and compared to HC/AC measurements in infants weighing below the 3rd percentile at birth. Asymmetric HC/AC was defined as >95th percentile for gestational age.

**Results:** Between January 2002 and December 2014, a total of 640 women with treated CHTN underwent serial sonograms, with 256 (40%) giving birth to infants weighing between the 25th and 75th percentiles and 65 (10%) delivering an infant weight below the 3rd percentile. Using random-effects modeling to generate a gestational age-specific HC/AC curve, the infants with birth weights below the 3rd percentile had HC/AC ratios above the 95th percentile for all gestational ages when compared with 25th–75th percentiles ( $P < .001$ ), suggesting ubiquitous asymmetric fetal growth restriction. Sonographic identification of these discordant biometric parameters is significantly increased beginning at 25 weeks' gestation and is most easily identified at 29 weeks' gestation.

**Conclusions:** Women with CHTN requiring treatment are at increased risk for severe fetal growth restriction, and discordant biometric parameters, viz increased HC/AC, identify a significant proportion of asymmetric fetal growth in this high-risk cohort.

#### 2384913 The Doppler Transitional Phase in Severely Premature Intrauterine Growth-Restricted Fetuses

**Ana Tobiasz,\* Luis Gomez, Giancarlo Mari**

*University of Tennessee Health Science Center, Memphis, TN USA*

**Objectives:** We previously showed in a small cohort that premature fetuses with growth restriction (FGR) experience a transitional phase in the main vessels before persistent Doppler worsening. We sought to investigate if this phase is different when FGR is diagnosed <28 vs >28 weeks.

**Methods:** Prospective cohort. Serial Doppler studies were performed in FGR (estimated fetal weight <10th percentile) from diagnosis (group 1, <28 weeks; group 2, >28 weeks) until delivery or demise in the umbilical artery and vein (UA and UV), middle cerebral artery (MCA), and aortic isthmus (AI). At least 3 studies were performed in each fetus, consisting of 3 different sets of waveforms per vessel. A transitional phase was defined when normal and abnormal flow patterns were identified during the same exam.

**Results:** A total of 301 Doppler studies were performed (range, 3–16 per fetus) in 95 FGR (group 1 = 65; group 2 = 23). Median latency from diagnosis to delivery or demise was 6.3 (range, 1–54) days in group 1 and 1 (range, 1–23) days in group 2 ( $P < .01$ ). There were more fetal and neonatal deaths (27% and 47%, respectively) in group 1 than in group 2

(6% and 6%;  $P = 0.01$ ;  $P < .001$ , respectively). Doppler transitional phases were noted in the UA (33 fetuses), MCA (25), UV (17), and AI (2); in 16 fetuses, transitional phases were seen simultaneously in  $>1$  vessel. The latency period from transitional phases to persistent worsening Doppler was longer for all vessels among fetuses in group 1 (Table 1;  $P < .01$ ).

**Conclusions:** Doppler transitional phases are common findings in severe premature FGR. In our cohort, the latency period from a transitional phase to persistent Doppler worsening was longer in those diagnosed  $<28$  weeks. This information should be considered when managing severe premature FGR.

Table 1. Days of Doppler Findings Before Delivery or Demise

	UA					MCA PI			MCA PSV			UV					AI	
	NL	NL-AF	AF	AF-RF	RF	NL	NL-EL	EL	NL	NL-EL	EL	NL	PULS	DPULS	BIPH	RF	NL	RF
$<28$ wk	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	4	11	3.5
Median	22	6	19	3	5	3	2	5	6	3	5	9	4	7	3	4	1	5
Mean Range	1–43	1–12	1–38	1–7	1–20	1–40	1–11	1–25	1–40	1–14	1–31	1–50	1–17	1–18	1–5	4	1–40	1–36
$\geq 28$ wk	1	1	1	1	1	1	1	1	1	1	1	1	1	1	NA	NA	5	4
Median	5	4	3	1	1	1	1	2	2	1	1	2	1	3	NA	NA	6	4
Mean Range	1–10	1–9	1–6	1	1	1	1	1–10	1–20	1	1–5	25	1–5	1–5	NA	NA	1–14	3–5

$P < .01$  for all vessels.

## E-POSTERS

## Basic Science and Instrumentation

**2363123 A Comparison of Different Hydrophones in High-Intensity Ultrasound Pressure Measurements**

Yunbo Liu,\* Keith Wear

US Food and Drug Administration, Silver Spring, MD USA

**Objectives:** A reliable characterization of the acoustic field distribution is important for both patient safety and treatment efficacy during clinical high-intensity ultrasound applications. Even though acoustic hydrophones are used extensively in ultrasound dosimetry for pressure measurements, technical challenges still exist due to the highly intense, focused, and nonlinear acoustic field. Measurement inconsistencies using different hydrophones were reported to be on the order of 50% (Haller et al. *J Acoust Soc Am* 2012; 131:1121–1130).

**Methods:** In this work, 4 different acoustic hydrophones were compared for pressure measurement: a piezoceramic needle hydrophone designed for high-intensity focused ultrasound (HIFU), a polyvinylidene difluoride capsule hydrophone with a small sensing element, and 2 fiber-optic acoustic hydrophones. The focal pressure waveform and field characteristics of a 3.3-MHz single element HIFU transducer were measured at several acoustic power levels from 0.25 up to 20 W. Complex deconvolution between the hydrophone output signal and the hydrophone frequency-dependent complex sensitivity was performed to obtain the focal pressure waveform.

**Results:** With increasing acoustic power output, the deconvolved focal waveform, compressional pressure (up to 20 MPa), rarefactional pressure (up to 8 MPa), and lateral focal beam profile are compared, and possible reasons for differences are evaluated. Rarefactional pressure  $P_-$  varied the same as compressional pressure  $P_+$  (12.5% vs 12.6%). In particular, the effect of hydrophone spatial averaging (12% for the needle hydrophone) and local nonlinear propagation parameters (up to 2.0) were compared and discussed between the different hydrophone sensors.

**Conclusions:** This study aimed to compare measurement accuracy using different acoustic hydrophones and assess the measurement variation due to sensor selection and analysis method during high-intensity pressure field characterization.

**2380280 Quantitative Assessment of Damage During Myocardial Cavitation Enabled Therapy: A Parametric Study in a Rodent Model**Yiyang Zhu<sup>1,2</sup>,\* Douglas Miller<sup>1</sup>, Chunyan Dou<sup>1</sup>, Xiaofang Lu<sup>1</sup>, Oliver Kripfgans<sup>1</sup><sup>1</sup>Radiology, <sup>2</sup>Biomedical Engineering, University of Michigan, Ann Arbor, MI USA

**Objectives:** Myocardial cavitation enabled therapy (MCET) has been proposed as a means to achieve minimally invasive myocardial reduction using ultrasound to produce scattered microlesions by cavitating contrast agent microbubbles. The purpose of this study was to validate our novel computer-aided microlesion analysis method (Zhu et al. *IEEE Trans Biomed Eng* 2015; 62:717–727) by comparison with manual counting for a wide range of treatment parameters.

**Methods:** Rats were treated in a heated water bath using burst mode focused ultrasound at a 1.5-MHz center frequency. The treatment impact was varied over a range of therapeutic conditions, including contrast agent dose and infusion rate as well as exposure amplitude and exposure pulse modulation. For the latter, square versus Gaussian pulse train modulations of the acoustic pressure were investigated. Gaussian modulation was to simulate exposures using a sweeping therapeutic beam. Evans blue staining indicated lethal cardiomyocyte injury by fluorescence microscopy of frozen sections. Our above-cited quantitative scheme was compared to manual scoring.

**Results:** Macrolesions are generated as an accumulation of probability-driven microlesion formations. Macrolesions populate radially from the beam axis with radii from 0.1 to 1.6 mm, for peak negative exposure amplitudes of 2 and 4 MPa, respectively. The Gaussian modulations were found to maintain an acceptable macrolesion volume. The contrast agent dose scaled with the treatment effect, and changes in infusion rates did not significantly influence microlesion production. For low microlesion densities, manual and computer evaluations were in good agreement, while for higher densities, manual scores became problematic, and the computer method may have produced a more realistic evaluation of the total microlesion yield.

**Conclusions:** For lesion generation planning in treatment of hypertrophic cardiomyopathy, control of MCET is crucial. This study validated the computer-aided assessment of treatment volumes for moderate to high microlesion densities. Furthermore, the results demonstrated that the swept beam would not negatively affect the cavitation nucleation, thus allowing rapid lesion production over clinically relevant volumes of tissue.

**2382998 Lessons Learned During a Clinical Implementation of DICOM Structured Reporting Across a Radiology Ultrasound Practice**

Scott Stekel,\* Samir Budimlic, Joel Wolery, Nicole Strissel, Jose Villarama, Shyamala Bhat, Janice Pascoe, Donald Tradup, Nicholas Charboneau, Jason Tjelta, Nicholas Hangiandreou

Radiology, Mayo Clinic, Rochester, MN USA

**Objectives:** Digital Imaging and Communications in Medicine (DICOM) structured report (SR) transfer of ultrasound measurements to scanners, picture archiving and communication systems (PACS), and other systems may improve efficiency and report quality. Implementations are complex, involving tagging and mapping of measurements across multiple systems, and the DICOM ultrasound (US) SR standard is lacking. We have completed an implementation supporting all vascular, gynecologic, abdominal, small parts, and pediatric imaging in our US practice. We share lessons learned interfacing SR data between scanner and PACS.

**Methods:** A multispecialty clinical project team worked closely with our scanner and PACS vendors to complete this project, which went live in May 2015. We noted significant challenges during the implementation and developed strategies for overcoming them.

**Results:** Challenges encountered included the following: Many factors can cause SR data output variability, including scanner models and vendors, scanner software (SW) versions, factory vs user-defined measurements, and measurement acquisition details such as measurement group (eg, abdominal vs gynecologic) or use of an exam protocol function. Due to limited clinical SR use, scanner vendors cannot always predict how their systems will respond in practice; SW release notes may be incomplete. User-defined measurement (“calc package”) design is often initially driven by the aesthetic appearance of the resulting measurement report on the scanner and may not be ideal for driving data-centric SR output; some reimplementations of measurements may be needed. Multiple copies of test exams modeled on clinical practice are essential for verification. Variations between like exams may reveal SR encoding novelties. Visual comparison of the scanner report pages with the PACS-presented measurements is tedious but essential. Loading stored sets of test exams and resending via SR can help test different scanner SW versions, but version-specific acquisitions are still required. Software (eg, the “Offis DCMTC DICOM Toolkit”) to evaluate SR data independent of the PACS is essential.

**Conclusions:** Comprehensive implementation of SR in practice is beneficial but challenging. Knowledge of potential pitfalls should assist in implementation.



**2384869 Superficial Breast Lesions: Does Ultrasound Need Some Better Adjustment to Be Able to Characterize?****Abdelmohsen Hussien***Radiology, University of Rochester, Rochester, NY USA*

**Objectives:** In most centers, the breast is scanned utilizing a 12-MHz transducer. This may be defective in evaluation of superficial breast lesions and may make a solid lesion look like a cyst. This presentation will focus on the role of ultrasound in evaluation of a variety of superficial breast lesions that are close to the skin and will also focus on changing ultrasound parameters for better evaluation of these lesions. It will also discuss differentiating solid from cystic superficial lesions. This includes choosing the high-frequency transducer, changing the focus depth, and the use of Doppler ultrasound. This presentation will be supported with various examples and will illustrate the difference in ultrasound appearance by changing to higher-frequency transducers.

**Methods:** This presentation will discuss evaluation of breast lesions by using ultrasound and Doppler evaluation of different types of superficial breast lesions, including cystic, benign solid, and malignant solid biopsy-proven lesions. iU22 and EPIQ 7 ultrasound systems were used with the use of 12-, 17-, and 18-MHz transducers.

**Results:** Superficial breast lesions are better characterized by the use of a high-frequency transducer along with Doppler.

**Conclusions:** Radiologists should be aware that some malignant superficial lesions can be overlooked or misinterpreted as benign cysts with the use of the everyday 12-MHz transducer. Characterization and differentiation between various types of breast superficial lesions are better achieved by the use of the high-frequency transducer: for example, 17 or 18 MHz.

**2385119 Super-Resolution and Lateral Beam Patterns****Shujie Chen, Kevin Parker\****Electrical and Computer Engineering, University of Rochester, Rochester, NY USA*

**Objectives:** Conventional B-mode ultrasound images suffer from their broad lateral beam patterns. To increase the image resolution, specific imaging strategies and postprocessing procedures are designed so that the lateral cuts are sampled to have their Z-transform zeros away from the unit circle, enabling the use of stable inverse filters. As a result, super-resolution is achieved.

**Methods:** Unfortunately, the point spread functions (PSF) from typical ultrasound imaging systems lead to inverse filters that are unstable. It is found that when properly shaped and sampled, a lateral cut can have a stable inverse filter. Hence, a 1D parameterized lateral inverse filter is designed from the down-sampled PSF using an integrated Gaussian model. To deconvolve an image, specific transverse down-sampling is applied to the radiofrequency signal to produce sub-images. Each sub-image is convolved separately using the designed inverse filter bank to form a partial deconvolution image. All the partial images are interleaved to generate the final result. Regarding the noise amplification, median filtering and conditioning of the inverse filters are applied accordingly.

**Results:** Both simulations in Field II (Jensen 1996) and experiments using the Verasonics scanner were performed. In Field II, models for the ATL L12-5 38-mm transducer, a 7.5-MHz transducer with 128 active elements, were simulated for a phantom around 60 mm deep. An ATL L7-4 transducer operating at 5 MHz focusing 50 mm with the Verasonics scanner was used to image wires in the water, the ATS 535 QA phantom, and tissues. By applying the proposed methods, stable inverse filters were found; the lateral opening of a nominally 4-mm-diameter cyst in the phantom was increased from 1.5 to 3.0 mm; and images with improved lateral resolution were achieved.

**Conclusions:** In the context of the Z-transform and the deconvolution model, an inverse filter approach has been designed. Examples are shown by applying the proposed method using both Field II and the Verasonics scanner. Super-resolution improvement is achieved by specific design of beam pattern and sampling.

**2385593 Different Methods of Ultrasound Training for Medical Students at Cerrahpasa School of Medicine****Vira Fomenko,\* Ramin Rajaii, Nicholas Taylor, Helene Nepomuceno, Soe Thein, Eric Dang, Joseph Zakaria, Michael Niechayev, Brittany Mitchell, J. Christian Fox**  
*University of California, Irvine School of Medicine, San Jose, CA USA*

**Objectives:** University of California Irvine medical students traveled to Cerrahpasa School of Medicine in Istanbul, Turkey, to teach medical students bedside ultrasound (BUS). Turkey suffers from economic challenges, making ultrasound an indispensable, cost-effective, and minimally invasive medical tool. Teaching medical students BUS indicates that it can be efficiently taught worldwide to maximize health care productivity. We aimed to compare different methods of teaching BUS in a 1-week course.

**Methods:** Three teaching methods were compared: lecture with hands-on training, podcast with hands-on training, and hands-on training alone. We predict that lecture with hands-on training would be most effective. BUS was taught in four 1-week sessions, of which each student could only attend one. One hundred thirty students participated in the BUS course. Hands-on training sessions accommodated 3 or 4 students per hour per group. Topics covered were (1) knobology, (2) cardiac, (3) abdominal, (4) pulmonary, and (5) focused assessment with sonography for trauma (FAST). Students were randomly assigned to 3 groups. Before the hands-on training, group A attended the lecture, group B watched the podcast, and group C had neither. All students took a pre- and post-training written exam. At the end, students were given a practical where they completed a FAST scan.

**Results:** Preliminary data indicate that students' pre- to post-training scores increased by 47% in group A, by 44% in group B, and by 40% in group C. Pre-test written scores showed no significant difference using analysis of variance (ANOVA;  $F = 0.986$ ;  $P = .377$ ); however, there was a significant increase between the groups on the post-test using ANOVA ( $F = 3.241$ ;  $P = .044$ ). The practical exam average was significantly different: 80% for group A, 81% for group B, and 70% for group C ( $F = 3.295$ ;  $P = .042$ ).

**Conclusions:** These preliminary results suggest that there is a difference in the didactic efficacy of different methods used to teach medical students basic ultrasound concepts as well as practical ultrasound skills. Specifically, watching a podcast in combination with attending a hands-on session improves the development of practical ultrasound skills.

**2385633 An Overview of Ultrasound Scanner Display Performance and Management Features****Donald Tradup,\* Scott Stekel, Zaiyang Long, Nicholas Hangiandreou***Radiology, Mayo Clinic, Rochester, MN USA*

**Objectives:** Unlike other volumetric and projection imaging modalities, images in an ultrasound (US) exam do not sample all tissues in the patient region of interest, for presentation to the radiologist in the reading room. If pathology is not seen on the scanner, it is unlikely to end up in the reading room. Therefore US scanner displays require increased diagnostic (dx)-level performance compared with other modality displays. Our aim is to benchmark US scanner display performance and availability of features for effectively managing display quality.

**Methods:** We employed standard procedures for US scanner display setup and quality control (QC) to manage 138 systems (26 models from 8 vendors) in our clinical practice for both dx imaging and procedures. Setup involves specifying luminance operating points (especially maximum [Lmax]). QC includes assurance that Lmax meets setup specs, an artifact inspection, and an overall visual image quality assessment. Ideal displays would provide a high Lmax value, Digital Imaging and Communications in Medicine (DICOM) grayscale calibration and validation tools, test patterns needed for setup and QC, and luminance controls with

visible settings that are locked out from users. We reviewed QC records and summarized compliance with these desired characteristics.

**Results:** Eighty-four percent of scanners had  $L_{max} \geq 120$  cd/m<sup>2</sup>; 11% had  $L_{max} \geq 150$  cd/m<sup>2</sup>, with a maximum of 207 cd/m<sup>2</sup>, all well below the 350-cd/m<sup>2</sup> level recommended by the American College of Radiology for general dx interpretation. Table 1 summarizes availability of display-related features. Ninety-two percent of the systems had flat panel displays, the rest being cathode ray tubes.

**Conclusions:** US scanner displays are critical for optimizing patient benefit, but current systems are generally lacking in needed performance and features. Increased physician and sonographer focus on scanner display performance may drive improved capabilities in future commercial imaging systems.

Table 1. Percentages of the 26 Scanner Models That Provide the Indicated Feature

Luminance features	
DICOM GSDF calibration capability	8%
Luminance control and visible settings	23%
Luminance control lockout	17%*
Accessible test patterns	
Luminance measurement (2–5 patterns)	35%
Dark and bright flat fields, artifact inspection	38%
General image quality: eg, SMPTE	31%

\*Only systems with luminance control are considered.

## Cardiovascular Ultrasound

### 2379959 Managing Low-Risk Clots in High-Risk Patients: A Case Report Showing Propagation of Unstable Peroneal Deep Vein Thrombosis to Saddle Pulmonary Embolism During Serial Ultrasound Scanning

*Marcia Bockbrader<sup>1</sup>,\* Jayesh Vallabh<sup>1</sup>, Kevin Donlon<sup>1</sup>, Matthew Fanous<sup>1</sup>, David Bahner<sup>2</sup>*

<sup>1</sup>Physical Medicine and Rehabilitation, <sup>2</sup>Emergency Medicine, Ohio State University, Columbus, OH USA

**Objectives:** To illustrate the propagation of low-risk deep vein thrombosis (DVT) to pulmonary embolism (PE) during serial venous duplex scanning (VDS) in a high-risk patient.

**Methods:** Case report of a 53-year-old hemiparetic male admitted to inpatient rehabilitation after an ischemic stroke with hemorrhagic conversion and craniectomy. He was monitored with serial VDS, received mechanical DVT prophylaxis, and began prophylactic heparin on post-stroke day (PSD) 22. On PSD 24, he developed right calf swelling with peroneal DVT diagnosed by VDS. He continued on prophylactic-dose anticoagulation until his next serial VDS on PSD 31, which visualized his right peroneal DVT and found a new partially occlusive thrombus in his right proximal femoral vein. The femoral DVT disappeared during scanning; he developed tachycardia, tachypnea, and oxygen desaturations and was found to have a large acute saddle PE on a pulmonary computed tomographic angiogram. He was then treated with therapeutic anticoagulation and inferior vena cava (IVC) filter placement.

**Results:** One of 6 calf DVTs propagate to become proximal DVTs or PEs. Current recommendations (Henry, 2014) stratify treatment by patient risk, with 1 month of therapeutic anticoagulation recommended for high-risk patients and serial scanning for both low- and high-risk patients with contraindications to anticoagulation. Implicit is the assumption that serial VDS carries minimal risk for clot propagation. However, in the early stages of DVT formation, unstable clots that are sessile with tenuous adhesion to vessel walls may be susceptible to being dislodged with pressure.

**Conclusions:** This case shows that conservative management of DVTs with serial VDS may not be benign in the acute stage of thrombus formation, when clots are most likely to be unstable. Rehabilitation pa-

tients often fall into the high-risk category for DVTs due to immobility but may also have conditions that are contraindications for anticoagulation. In such high-risk patients who have low-risk clots, IVC filter placement may be preferred to serial VDS to prevent the morbidity and mortality associated with PE.

### 2381853 Carotid Body Abnormalities: Analysis of a Series of Cases Found Incidentally During Carotid Ultrasound

*Nathalie Garbani*

*Clinical, Life Line Screening, Independence, OH USA*

**Objectives:** Case series.

**Methods:** Review of incidental findings seen during carotid artery screening of over 1 million patients between January 1, 2014, and August 31, 2015, revealed 89 cases of carotid body tumors. Self-reported medical histories, systolic blood pressure records at the time of the screening, and demographic data (including geographic location of main dwelling) were recorded and analyzed.

**Results:** The results suggest similar prevalence in regard to gender, with a female-to-male ratio of 3:1. However, race distribution suggested prevalence in Caucasians, and geographic distribution revealed 2 major clusters, 1 in people living at altitude over 5000 feet and 1 east of the Appalachian range.

**Conclusions:** Not applicable.

### 2381928 Handheld Ultrasound Versus Chest Radiography in the Coronary Care Unit

*Colin Phillips,\* Warren Manning*

*Cardiology, Beth Israel Deaconess Medical Center, Boston, MA USA*

**Objectives:** Goal-directed handheld ultrasonography (HHU) has the potential to revolutionize the diagnosis and care of critically ill patients, although few data exist comparing it to existing imaging technology. We sought to examine the performance of HHU compared to daily portable chest radiography (CXR) to detect common diagnoses in the coronary care unit.

**Methods:** An experienced (4 years) HHU user performed an HHU examination for the presence of interstitial edema ( $\geq 3$  comet tail artifacts) pneumonia (lung parenchyma consolidation), pericardial and pleural effusions, central line seen in the right ventricle, left atrial enlargement (left atrium diameter > aorta), and cardiomegaly (left ventricle larger than the scanning screen at 14 cm depth). Data were compared to the radiologist read of the CXR obtained within 30 minutes. HHU and CXR interpretations were performed blinded to the results of the other imaging modality.

**Results:** A total of 47 CXR and HHU exams were performed in 37 patients, with adequate quality in all studies. The most common CXR findings were central line position (66%) and pulmonary edema (45%). Overall performance of HHU to detect abnormalities was good, with sensitivity varying between 40% (pneumonia) and 100% for left atrial enlargement and specificity of 54% for left atrial enlargement and 100% for central line location (Table 1).

**Conclusions:** HHU is reasonably accurate in diagnosing common conditions in the coronary care unit with the added benefit of instantaneous bedside diagnosis and lack of ionizing radiation. Larger multicenter studies are needed to determine if the use of HHU could displace routine daily CXR in the coronary care unit.

Table 1

	Incidence, %	Sensitivity, %	Specificity, %	PPV, %	NPV, %
Interstitial edema	45	80	77	74	83
Pleural effusion	36	76	80	68	86
Pneumonia	11	40	95	50	93
Pericardial effusion	0	Undefined	81	0	100
Left atrial enlargement	13	100	54	24	100
Cardiomegaly	64	96	65	82	85
Central line	66	77	100	100	70

NPV indicates negative predictive value; and PPV, positive predictive value.

### 2385402 Contrast-Enhanced Ultrasound Assessment of Skeletal Muscle Perfusion Before and After Left Ventricular Assist Device Implantation

**Minakshi Mohanty<sup>1</sup>, Sabhya Gupta<sup>1,3</sup>, Maria Stanczak<sup>1</sup>, Ann Banks<sup>2</sup>, Lauren Trinsey<sup>2</sup>, Anush Sridharan<sup>1,4</sup>, Gordon Reeves<sup>2</sup>, Flemming Forsberg<sup>1\*</sup>**

<sup>1</sup>Radiology, <sup>2</sup>Cardiology, Thomas Jefferson University, Philadelphia, PA USA; <sup>3</sup>College of New Jersey, Ewing, NJ USA;

<sup>4</sup>Electrical and Computer Engineering, Drexel University, Philadelphia, PA USA

**Objectives:** To investigate muscle perfusion as a determinant of physical function in heart failure patients before and after receiving left ventricular assist device (LVAD) therapy.

**Methods:** Four patients scheduled for LVAD therapy signed informed consent to undergo contrast-enhanced ultrasound (CEUS) exams prior to LVAD implantation, 2 weeks after implantation, and 3 months after implantation as part of an ongoing Institutional Review Board–approved study. During each session, 2 CEUS exams were conducted on the quadriceps, 1 in a rest state and the other in a fatigue state. Muscle fatigue was achieved by performing knee extensor exercise, wherein the examiner used a handheld dynamometer (MicroFET 2; Hoggan Scientific, Salt Lake City, UT) to provide resistance equal to approximately 50% of the maximum knee extensor strength while the participant performed repeated knee extensions until the participant was unable to complete a repetition with 50% of the measured maximum knee extensor strength (maximum of 20 repetitions). Scanning was performed using an S3000 Helix scanner (Siemens Medical Solutions, Mountain View, CA) with a linear or curvilinear array during bolus injections of 0.3 mL of Definity (Lantheus Medical Imaging, North Billerica, MA). Three destruction-reperfusion sequences were acquired for each injection. Time-intensity curves were generated offline in MATLAB (MathWorks, Natick, MA) to estimate perfusion over the entire muscle. Perfusion was calculated as the slope of the curve from the time of contrast arrival to the peak intensity. The data were then compared using paired *t* tests.

**Results:** Perfusion values before and after exercise differed significantly ( $4.03 \pm 1.97$  vs  $5.48 \pm 2.48$  au;  $P = .042$ ). No significant differences were observed between perfusion data sets prior to LVAD implantation and 2 weeks and 3 months after LVAD implantation ( $P > .14$ ).

**Conclusions:** CEUS-estimated muscle perfusion appears to indicate physical function of heart failure patients. However, this study is ongoing, and more patient data are required to substantiate these preliminary results.

### 2385826 Pulsed Ultrasound Modulates the Depolarization of Cardiomyocytes in a Cell-Based Model

**Andrew Kohut**

Medicine, Drexel University, Philadelphia, PA USA

**Objectives:** Ultrasound can interact with tissue through non-thermal physical mechanisms to influence the electromechanical feedback circuit of cardiomyocytes and hold clinical potential as a noninvasive therapeutic tool in the heart. This study aims to assess the effect of ultrasound on cardiomyocyte depolarization in a cell-based model.

**Methods:** Cardiomyocytes were isolated from neonatal rat ventricular tissue and plated on microelectrode arrays to record action potentials and analyze depolarization patterns. A custom 2.5-MHz unfocused ultrasound transducer was directed at neonatal ventricular rat cardiomyocytes in culture. A function generator, with an amplified signal +51 dB, delivered acoustic energy at variable spatial-peak time-averaged intensities ( $I_{SPTA}$ ) in W/cm<sup>2</sup> at pulse durations of 2, 5, and 10 milliseconds, with burst periods (pulse repetition periods) of 100, 250, and 300 milliseconds. Multiple trials were conducted at each setting with 30 total trials, consisting of 30 seconds of continuous ultrasound exposure with a subsequent off interval of 1 minute.

**Results:** The rates of depolarization were assessed by the R-R interval durations (IDs) that were measured throughout the recording period. Prior to ultrasound delivery, the IDs were highly irregular: ID range, 0.3–3.6 seconds. As ultrasound was delivered in an asynchronous manner, using  $I_{SPTA}$  values of 0.03–0.24 W/cm<sup>2</sup> and pulse durations of 2 and 5 milliseconds, there was suppression/inhibition of cellular depolarization for 5–10 seconds during the first 15 seconds of the exposure period. Subsequent to this suppression/inhibition effect, the depolarization rate increased and demonstrated less R-R interval variability with IDs of 0.8–1.0 seconds ( $P < .05$ ) after ultrasound exposure. This decreased interval variability persisted after ultrasound exposure. The ID changes occurred in a predictable fashion in greater than 90% of recordings using these ultrasound exposure parameters.

**Conclusions:** Ultrasound can inhibit and modify the frequency of spontaneous electrical depolarizations of neonatal ventricular cardiomyocytes in a cell-based model. Our results demonstrate that pulsed ultrasound can influence the mechanotransduction pathways of cardiomyocytes in the mechanoelectric feedback circuit in a dose- and time-dependent manner.

## Contrast-Enhanced Ultrasound

### 2374736 Utility of Superb Microvascular Imaging for Visualizing Lesions in the Portal Vein

**Takaaki Sugihara,\* Toshiaki Okamoto, Kenichi Miyoshi, Tomomitsu Matono, Masahiko Koda, Hajime Isomoto**  
Tottori University Faculty of Medicine, Yonago, Japan

**Objectives:** Portal vein thrombosis is sometimes observed in hepatic cirrhosis and hepatic cancer. Superb Microvascular Imaging (SMI), developed by Toshiba Medical Systems, is a new imaging technology that enables visualization of low-velocity blood flow without use of a contrast agent. This study compared visualizing lesions in the portal vein among SMI in monochrome mode (mSMI) with conventional Doppler technology (Advanced Dynamic Flow [ADF]) and with contrast-enhanced ultrasound (CEUS).

**Methods:** The Aplio500 diagnostic ultrasound system and a 3.5-MHz convex probe were used. CEUS was performed for 6 patients after rapid intravenous injection of 0.01-mL/kg Sonazoid. The following items were evaluated: (1) capability visualizing lesions in the portal vein; (2) capability of detecting blood flow signals within lesions in the portal vein; (3) levels of blood flow signals (1, dotted; 2, unclear line; 3, clear thread and streak sign); and (4) diagnostic US findings (blood clot or tumor



thrombosis in the portal vein). Images were analyzed by 2 examiners and the agreement rate ( $\kappa$  coefficient) between them was calculated. Contrast-enhanced computed tomography was used as a gold standard.

**Results:** Among 11 subjects (7 men, 4 women), hepatic cirrhosis was found in 8, chronic hepatitis in 3, and concurrent liver cancer in 8. The definitive diagnosis was a blood clot thrombus in 6 cases and a tumor thrombus in 5 cases. The diagnostic accuracy was 64% for ADF, 91% for mSMI, and 91% for CEUS. Examination results agreed well between the examiners, with  $\kappa$  coefficients  $\geq 0.5$  for most evaluation items. However, in the item for evaluating the level of blood flow signals, only mSMI had a  $\kappa$  coefficient of 0.5.

**Conclusions:** The accuracy of mSMI was higher than that of ADF and comparable to that of CEUS in detecting lesions in the portal vein. Also, 2 examiners agreed that only mSMI clearly depicted blood flow signals within lesions. Taken together, these results indicate that mSMI is a useful and less-invasive technique for reproducible diagnosis of lesions in the portal vein.

### 2377135 Contrast-Enhanced Ultrasound: A Problem-Solving Tool in the Multimodality Evaluation of Hepatocellular Carcinoma

Eugenia Khorochkov<sup>1</sup>, \* Joel Mercer<sup>1</sup>, Stefanie Lee<sup>1,2</sup>

<sup>1</sup>Western University, London, Ontario, Canada; <sup>2</sup>McMaster University, Hamilton, Ontario, Canada

**Objectives:** To review the indications and technique for contrast-enhanced ultrasound (CEUS) in the evaluation of liver lesions in patients at risk for hepatocellular carcinoma (HCC). To demonstrate the application of CEUS as a problem-solving modality in the imaging diagnosis of HCC. To provide multimodality correlation between conventional US, computed tomography (CT), magnetic resonance imaging (MRI), and CEUS in cases of HCC.

**Methods:** This educational e-poster will cover: indications for CEUS; performing CEUS and image optimization; CEUS findings in the liver and HCC; and case examples of CEUS as a problem-solving tool.

**Results:** HCC enhancement patterns on CEUS classically mirror those of more traditional imaging modalities, where there is early arterial hyperenhancement with “washout” in the portal venous phase. In cases such as these, a biopsy is often not necessary to confirm the diagnosis of HCC. However, not all HCCs demonstrate this classic pattern on static imaging modalities such as CT and MRI, which is where dynamic CEUS can function as an effective problem-solving tool, allowing for assessment of lesion characteristics in real time. This is especially useful in cases of infiltrative HCC, where enhancement may vary in pattern and timing. We have also found it to be an effective tool for distinguishing bland versus tumor thrombus by monitoring the enhancement pattern on CEUS where CT and MRI have been equivocal. This differentiation can be essential for patient staging and surgical planning. An additional benefit to CEUS is that it can be used in patients for whom iodinated contrast or gadolinium are contraindicated (ie, allergy, renal failure).

**Conclusions:** CEUS is a safe alternative in patients with impaired renal function or allergy to other forms of intravenous contrast, providing superior temporal resolution with real-time assessment of blood flow, which offers advantages over conventional US or CT/MRI. It can be an effective problem-solving tool in equivocal or challenging cases of HCC diagnosis (eg, confirming tumor thrombus, infiltrative HCC, late arterial enhancement, and/or delayed washout). The technical limitations are similar to those of conventional US.

### 2377323 Combination of Conventional Ultrasound and Contrast-Enhanced Ultrasound in Transjugular Intrahepatic Portosystemic Shunt Follow-up: An Effective Method

Jean Ayoub

Ultrasound, University Hospital Trousseau of Tours, Tours, France

**Objectives:** Obstruction is a frequent transjugular intrahepatic portosystemic shunt (TIPS) complication, and its monitoring by ultrasound is ambiguous in the literature. The objective of this study was to demonstrate the efficacy of the color and pulsed Doppler velocity profile (CPDV) combined with contrast-enhanced ultrasound (CEUS) in assessment of TIPS dysfunction during 1 year for each patient.

**Methods:** Thirty-seven patients followed from 2007 to 2014 had baseline CPDV examinations 1 day before and 5 days after TIPS and follow-up at 1, 3, 6, 9, and 12 months, by the same operator. The results were correlated with those of the angiography. CEUS was used only in cases of doubt of shunt stenosis.

**Results:** After the procedure, portal vein and hepatic artery mean velocities increased by 270% and 162% ( $P = .0001$ ). The portal and hepatic artery flow volumes increased by 311% and 178% ( $P = .0001$ ). The portal vein pressure decreased by 71% ( $P = .0001$ ) immediately after TIPS placement. There was a moderate intraindividual correlation between portal vein pressure and portal mean velocity ( $P < .05$ ). Most of these hemodynamic parameters decreased with time. TIPS dilatation was decided in cases of reversed flow in portal branches or pronounced spectral curve dispersal on pulsed Doppler. CEUS was also used to confirm TIPS obstruction. CPDV and CEUS diagnoses were confirmed by angiography and portal vein pressure during dilatation.

**Conclusions:** Color Doppler ultrasonography combined with CEUS allowed quantitative and qualitative confirmation of the diagnosis of obstruction of TIPS. It is an effective and noninvasive method of evaluating shunt function. The success of this method requires adequate training of operators.

### 2378960 Contrast-Enhanced Ultrasound Liver Imaging Reporting and Data System for Diagnosis of Hepatocellular Carcinoma: Initial Proposal

Yuko Kono<sup>1</sup>, \* David Cosgrove<sup>2</sup>, Christoph Dietrich<sup>3</sup>, Hyun-Jung Jang<sup>4</sup>, Tae Kyoung Kim<sup>4</sup>, Andrej Lyschchik<sup>5</sup>, Fabio Piscaglia<sup>6</sup>, Claude Sirlin<sup>7</sup>, Juergen Willmann<sup>8</sup>, Stephanie Wilson<sup>9</sup>

<sup>1</sup>Medicine, University of California, San Diego, CA USA;

<sup>2</sup>Radiology, Hammersmith Hospital, Imperial College, London, United Kingdom;

<sup>3</sup>Medicine, Caritas Krankenhaus Bad Mergentheim, Bad Mergentheim, Germany;

<sup>4</sup>Radiology, University of Toronto, Toronto, Ontario, Canada;

<sup>5</sup>Radiology, Thomas Jefferson University, Philadelphia, PA USA;

<sup>6</sup>Medicine, University of Bologna, S. Orsola-Malpighi Hospital, Bologna, Italy;

<sup>7</sup>Radiology, University of California, San Diego, CA USA;

<sup>8</sup>Radiology, Stanford University, Stanford, CA USA;

<sup>9</sup>Radiology, University of Calgary, Calgary, Alberta, Canada

**Objectives:** Hepatocellular carcinoma (HCC) is the second leading cause of cancer-related death worldwide and is the fastest growing cause of cancer death in the United States. The American College of Radiology endorsed the Liver Imaging Reporting and Data System (LI-RADS) to standardize the reporting and data collection of computed tomography (CT) and magnetic resonance (MR) imaging for HCC. It is expanded here to also include contrast-enhanced ultrasound (CEUS) for the same indication.

**Methods:** A CEUS LI-RADS working group has developed an initial proposal of CEUS LI-RADS categories, an algorithm, and management recommendations. The working template is based on the already established LI-RADS for CT and MR imaging and its stated objectives to:

apply consistent terminology; reduce imaging interpretation variability and errors; enhance communication with referring clinicians; facilitate quality assurance and research; facilitate integration and correlation between imaging modalities; and enhance communication with and understanding by patients. The working template encompasses the range of possible observations from obviously benign through definitely malignant, including HCC. The algorithm begins with the baseline appearance of the observation as well as its enhancement characteristics in the arterial, portal venous, and late phases, following contrast injection.

**Results:** The CEUS LI-RADS algorithm is shown in pictorial display of LR-5, definitely HCC; LR-M, malignant but not specific for HCC; LR-4, probably HCC; and other less-concerning appearances down to LR-1, a definitely benign lesion. Unique aspects of CEUS considered in the algorithm include the real-time acquisition of images as compared with the more “snapshot” acquisition with CT and MR, the necessity of precise timing in seconds, and the importance of washout characteristics (timing and its intensity). Further, the CEUS algorithm recognizes the importance of a nodule-based approach for CEUS as compared to CT and MR.

**Conclusions:** This initial proposal for CEUS LI-RADS will extend the benefits of consistent reporting and terminology to US from its already recognized benefit for CT and MR scans. This should improve the status of CEUS in liver surveillance and diagnostic programs for HCC.

**2385721 Efficacy of Contrast-Enhanced Ultrasonography to Evaluate Metastatic Cervical Lymph Nodes Before and After Chemoradiotherapy of Head and Neck Cancer Patients**  
*Kiyoto Shiga, Shin-ichi Oikawa, \*Daisuke Saitoh, Katsunori Katagiri*

*Head and Neck Surgery, Iwate Medical University, Morioka, Japan*

**Objectives:** It is well known that angiogenic processes in growing tumors promote increased vessel density and structural abnormalities. The purpose of this study is to evaluate whether or not it is useful to diagnose metastatic tumors in lymph nodes by the vascular density and morphology using contrast-enhanced ultrasonography (CEUS) compared with other diagnostic modalities.

**Methods:** Nineteen patients with head and neck carcinoma from July 2014 to July 2015 were enrolled in this study. Written informed consent was obtained from each patient. Primary tumors were 8 in the hypopharynx, 4 in the oropharynx, 3 in the oral cavity, 1 in the nose, 1 in the larynx, 1 in the maxillary sinus, and 1 in the parotid gland. Clinical N classifications were 2 N1, 1 N2a, 12 N2b, and 4 N2c diseases diagnosed by a combination of physical examination, computed tomography, magnetic resonance imaging, and fluorodeoxyglucose-positron emission tomography. We used a HI VISION Preirus (Hitachi Medical Corporation) or LOGIQ E9 (GE Healthcare) for US examinations. For pretreatment examinations, the ultrasound contrast agent Sonazoid was injected intravenously into the cubital vein of the patients. Under contrast mode, movies of the image of metastatic lymph nodes of the patients were recorded, and obtained images were subjected to analysis by image-analyzing software we developed (IwmUltrasonic version 2.00; DITECT) previously. Remnant metastatic lymph nodes of 6 patients were evaluated by CEUS after chemoradiotherapy.

**Results:** When we scanned the metastatic lymph nodes of the patients, CEUS revealed a microvascular network in their lymph nodes to some extent and in some different patterns before chemoradiotherapy. After chemoradiotherapy, 1 of 6 patients showed an active microvascular network still existing in the metastatic lymph nodes. Salvage neck dissection was performed for this patient, and histopathologic examination revealed that there were viable cancer cells in these lymph nodes.

**Conclusions:** CEUS is thought to be quite useful to detect vascular networks in metastatic lymph nodes of head and neck cancer patients and even to evaluate the remnant cancer cells in these metastatic cervical lymph nodes after chemoradiotherapy.

**385785 Efficacy of Contrast-Enhanced Ultrasonography Compared With Color Doppler Imaging in Metastatic Cervical Lymph Nodes of Head and Neck Cancer Patients**  
*Kiyoto Shiga, \*Daisuke Saitoh, Shin-ichi Oikawa, Katsunori Katagiri*

*Head and Neck Surgery, Iwate Medical University, Morioka, Japan*

**Objectives:** It is well known that angiogenic processes in growing tumors promote increased vessel density and structural abnormalities. The purpose of this study is to evaluate the vascular density and morphology in metastatic lymph nodes by contrast-enhanced ultrasonography (CEUS) compared with color Doppler imaging.

**Methods:** Eighteen patients with head and neck squamous cell carcinoma from January 2014 to March 2015 were enrolled in this study. Primary tumors were 8 in the oral cavity, 4 in the hypopharynx, 4 in the oropharynx, 1 in the larynx, and 1 of unknown origin. Clinical N classifications were 3 N1, 1 N2a, 9 N2b, and 5 N2c diseases diagnosed by a combination of physical examination, computed tomography, magnetic resonance imaging, and fluorodeoxyglucose-positron emission tomography. We used a HI VISION Preirus (Hitachi Medical Corporation) or LOGIQ E9 (GE Healthcare). The ultrasound contrast agent Sonazoid was injected intravenously into the cubital vein of the patients. Under contrast mode, movies of the image of metastatic lymph nodes of the patients were recorded, and obtained images were subjected to analysis by image-analyzing software we developed (IwmUltrasonic version 2.00; DITECT) previously.

**Results:** When we scanned the metastatic lymph nodes of the patients, 5 of 18 patients showed no signs of color Doppler images in their lymph nodes. However, CEUS revealed a microvascular network in these lymph nodes to some extent. Although 13 patients showed active color Doppler images in their lymph nodes, their vascular patterns were different from the images constructed by CEUS. Only 4 patients showed a similar pattern of vascular images. Vascular densities calculated by our software of the patients who showed no signs of Doppler images in their lymph nodes were smaller than those of the patients who showed active color Doppler images.

**Conclusions:** CEUS is thought to be quite useful to detect vascular networks in metastatic lymph nodes of head and neck cancer patients more accurately than color Doppler imaging.

## Elastography

**2374468 Assessing Deep Venous Thrombosis by Compression Ultrasound and Strain Imaging Using Acoustic Radiation Force Impulse Imaging: Preliminary Report**  
*Grzegorz Malek<sup>1</sup>, \*Grzegorz Aderek<sup>2</sup>, Witold Tomkowski<sup>1</sup>, Monika Majdanska<sup>2</sup>, Pawel Kuca<sup>1</sup>, Artur Maliborski<sup>2</sup>, Krzysztof Duda<sup>2</sup>*

*<sup>1</sup>Radiology, Institute of Tuberculosis and Pulmonary Diseases, Warsaw, Poland; <sup>2</sup>Radiology, Military Institute of Medicine, Warsaw, Poland*

**Objectives:** A properly assessed blood clot (acute or chronic) is the key source of information for staging of deep venous thrombosis (DVT) and for appropriate treatment. Over time, the blood clot becomes hardened. Strain imaging allows staging of clots and may help in assessing the effectiveness of treatment. VirtualTouch IQ is an implementation of acoustic radiation force impulse (ARFI) imaging allowing one to evaluate displacement and velocity of shear waves in many points in an appropriate region of interest. The purpose of this study was to assess the ability of sonographic strain imaging using ARFI technology to distinguish acute from chronic DVT.

**Methods:** Twenty-five patients with acute DVT and 25 with chronic DVT (>8 months) were studied. Compression ultrasound and ARFI imaging were performed with a 4–9-MHz linear array. VirtualTouch IQ imaging was used to assess clot properties. We compared shear wave velocity and displacement in 5 or 6 points in each clot. Relative thrombus echogenicity was assessed by comparing to the adjacent arterial lumen. Statistical analysis was performed with the Mann-Whitney *U* test and receiver operating characteristic analysis.

**Results:** The velocity of shear waves in patients with chronic DVT was significantly higher than in the group with acute DVT. Measured displacement was significantly lower in chronic DVT than in acute DVT.

**Conclusions:** Strain imaging is more accurate and specific than thrombus echogenicity evaluation. Assessment of thrombus aging using ARFI imaging (VirtualTouch IQ) is helpful in evaluation of acute DVT and post-thrombotic syndrome. Further investigations must be done.

### 2383331 Virtual Analysis of the Pancreas in Type 2 Diabetes by Ultrasound Acoustic Radiation Force Impulse Quantification Chunxiang Jin,\* Yu He, Juanjuan Zheng, Hui Wang Third Hospital of Jilin University, Changchun, China

**Objectives:** To study the elastic properties of the pancreas in patients with type 2 diabetes.

**Methods:** Fifty patients with type 2 diabetes mellitus (DM group) and 25 healthy persons (control group) were included and underwent conventional sonography and virtual touch tissue quantification (VTQ). For every person, the thickness and the shear wave velocities (SWVs) of the pancreatic head, body, and tail were measured, respectively. Because of the interference of gas, the total numbers of pancreatic heads, bodies, and tails examined were 41, 50, and 35, respectively.

**Results:** The thickness of the pancreatic body in the DM group was significantly lower than that in the control group ( $P < .05$ ). The local shear wave velocity of the pancreatic head, body, and tail in the DM group was significantly higher than that in control group ( $P < .05$ ).

**Conclusions:** Acoustic radiation force impulse imaging with VTQ demonstrated a difference in pancreas stiffness between patients with type 2 diabetes and healthy persons.

Table 1

	Control	DM
Thickness, cm		
Head	1.75 ± 0.30	1.73 ± 0.22
Body	1.43 ± 0.18	1.25 ± 0.20 <sup>a</sup>
Tail	1.50 ± 0.20	1.40 ± 0.23
SWV, m/s		
Head	1.04 ± 0.06	1.09 ± 0.10 <sup>a</sup>
Body	1.08 ± 0.07	1.29 ± 0.12 <sup>a</sup>
Tail	1.04 ± 0.07	1.10 ± 0.08 <sup>a</sup>

<sup>a</sup> $P < .05$  compared with control group.

### 2384549 Noninvasive Assessment of Liver Fibrosis Using Shear Wave Elastography in Patients With Chronic Liver Disease Tamami Abe,\* Hidekatsu Kuroda, Yasuhiro Takikawa Division of Hepatology, Department of Internal Medicine, Morioka, Japan

**Objectives:** Shear wave elastography (SWE) is a medical imaging modality in which tissue elasticity is estimated by measuring the shear wave speed. The aim of the present study was to evaluate the correlation between the liver stiffness measurement (LSM) by SWE and the liver fibrosis stage and to evaluate the accuracy of the LSM in comparison to the measurement of serum fibrosis markers (APRI, FIB-4, and platelets) in the prediction of significant and advanced fibrosis.

**Methods:** We consecutively analyzed 100 patients with chronic liver disease (CLD; 70 with hepatitis C virus and 30 with nonalcoholic fatty liver disease). LSM was performed 5 times at the same site on the day of the liver biopsy procedure. The biopsy specimens were reviewed by a blinded pathologist using the METAVIR criteria. Significant fibrosis was defined as stages F $\geq$ 2 and F $\geq$ 3, while advanced fibrosis was defined as stage F4. The accuracy of the prediction was analyzed using receiver operating characteristic curves.

**Results:** The LSMs for each stage of fibrosis were as follows: 1.43 ± 0.21 m/s in F0 ( $n = 30$ ), 1.54 ± 0.25 m/s in F1 ( $n = 36$ ), 1.66 ± 0.32 m/s in F2 ( $n = 8$ ), 2.03 ± 0.23 m/s in F3 ( $n = 14$ ), and 2.23 ± 0.21 m/s in F4 ( $n = 10$ ). A steady stepwise increase in the elasticity was correlated with the staging of liver fibrosis ( $P < .0001$ ). The diagnostic accuracies of the LSM in the prediction of stages F $\geq$ 2, F $\geq$ 3, and F4 were 0.901 (95% confidence interval [CI], 0.843–0.961;  $P < .0001$ ), 0.956 (95% CI, 0.928–0.984;  $P < .0001$ ), and 0.952 (95% CI, 0.926–0.977;  $P < .0001$ ), respectively. The cutoff values of the LSM for the prediction of stages F $\geq$ 3 and F4 were 1.81 m/s with 96.2% sensitivity and 85.1% specificity and 2.01 m/s with 98.7% sensitivity and 89.8% specificity, respectively. The diagnostic accuracy of the LSM was not significantly different from that achieved with the measurement of the serum levels of hyaluronic acid and type IV collagen 7S.

**Conclusions:** SWE was significantly correlated with the severity of liver fibrosis and was useful for predicting significant and advanced fibrosis. The level of accuracy was comparable to that achieved with the measurement of APRI, FIB-4, and platelets in CLD.

## Emergency and Critical Care Ultrasound

### 2339640 Mobile Echogenic Material on Ocular Ultrasound Is Not Always Pathologic: A Cross-sectional Survey in an Asymptomatic Emergency Department Population Gavin Budhrani,\* Jennifer Cronsell, Michele Schroeder<sup>3</sup> <sup>1</sup>Emergency Medicine, Baystate Medical Center, Springfield, MA USA; <sup>2</sup>Emergency Medicine, Bridgeport Hospital, Bridgeport, CT USA; <sup>3</sup>Emergency Medicine, Baystate Medical Center, South Hadley, MA USA

**Objectives:** Bedside ultrasound is an adjunct to standard examination techniques in emergency department patients with ocular trauma or acute vision loss. Several pathologic conditions have similar appearances on ultrasound and may even overlap with normal age-related changes. One approach that clinicians often use is to assume that unilateral findings visible at normal gain are acute, while bilateral findings requiring high gain are chronic, especially in the elderly population. To date, no ultrasound studies have systematically evaluated this assumption. Our objective is to determine the prevalence of monocular and binocular mobile echogenic material (MEM) in the posterior ocular chamber at normal and high gain levels and to evaluate if it increases in prevalence with age in an asymptomatic population.

**Methods:** We conducted a cross-sectional survey of 105 asymptomatic subjects aged 20–89 years and evaluated each subject's eyes for the presence of MEM at both normal and high gain levels.

**Results:** Ultrasound scans were obtained on a total of 105 subjects (210 eyes). At normal gain levels, MEM was present in 1 subject unilaterally (0.95%; 95% confidence interval, 0.0%–5.0%). At high gain levels, MEM was present in 28.6% (30/105) of subjects. Of the subjects with MEM at high gain, 60% (18/30) had unilateral MEM. MEM at high gain was found more frequently with advancing age, being present in 23 subjects older than 59 years, compared with 7 subjects 59 years and younger (51.1% vs 11.7%;  $P < .001$ ).

**Conclusions:** Our findings suggest that MEM in the posterior chamber visualized at high gain levels is relatively common and may not be pathologic, even if unilateral and occurring at a relatively young age.



Table 1. Subjects with MEM at High Gain by Age Strata

Age, y	Eyes With MEM, n (%)	Subjects With MEM, n (%)	Subjects With Unilateral MEM, n (%)	Subjects With Bilateral MEM, n (%)
20–29 (n = 15)	0 (0)	0 (0)	0 (0)	0 (0)
30–39 (n = 15)	4 (13.3)	3 (20)	2 (13.3)	1 (6.7)
40–49 (n = 15)	4 (13.3)	2 (13.3)	0 (0)	2 (13.3)
50–59 (n = 15)	3 (10)	2 (13.3)	1 (6.7)	1 (6.7)
60–69 (n = 15)	9 (30)	8 (53.3)	7 (46.7)	1 (6.7)
70–79 (n = 15)	13 (43.3)	9 (60)	5 (33.3)	4 (26.7)
80–89 (n = 15)	9 (30)	6 (40)	3 (20)	3 (20)
All (n = 105)	42 (20)	30 (28.6)	18 (17.1)	12 (11.4)

### 2366290 A Proposed Milestone for Pediatric Emergency Medicine Point-of-Care Ultrasound Competency

**Delia Gold<sup>1</sup>, \* Jennifer Marin<sup>2</sup>, Demetris Haritos<sup>3</sup>, Melissa Skaugse<sup>4</sup>, Jennifer Kline<sup>6</sup>, Rachel Stanley<sup>1</sup>, David Bahner<sup>4</sup>**

<sup>1</sup>Pediatrics, Nationwide Children's Hospital, Columbus, OH USA; <sup>2</sup>Pediatrics, Children's Hospital of Pittsburgh, Pittsburgh, PA USA; <sup>3</sup>Pediatrics, Children's Hospital of Michigan, Detroit, MI USA; <sup>4</sup>Emergency Medicine, Ohio State University Wexner Medical Center, Columbus, OH USA; <sup>5</sup>Emergency Medicine, C. S. Mott Children's Hospital, Ann Arbor, MI USA; <sup>6</sup>Nationwide Children's Hospital, Columbus, OH USA

**Objectives:** The Accreditation Council for Graduate Medical Education (ACGME) developed milestones for physician assessment in many subspecialties. Point-of-care ultrasound (POCUS) is one of 23 designated milestones in emergency medicine (EM); however, there are no specific milestones for pediatric emergency medicine (PEM) POCUS competency. Our objective was to assess PEM provider self-evaluation of POCUS skills using a modified assessment tool (MAT) based on the EM milestones.

**Methods:** This was a electronic survey of PEM faculty and fellows at 4 Midwestern pediatric academic centers. The survey included demographics, POCUS experience, and the MAT. Participants rated their competency level using the MAT with 2 established PEM ACGME milestones included for comparison. All milestones were scored from levels 1–5; 5 indicates highest competency. The Fisher exact test evaluated the association between training level and previous ultrasound experience with respect to the MAT.

**Results:** The response rate was 89% (123/138); 70.7% were PEM attending physicians and 29.3% PEM fellows. Eleven percent reported no EM POCUS training, and 17.4% reported no PEM POCUS training. On the MAT, 69.9% selected competency level 1 or 2 for POCUS in pediatric patients. In contrast, 54.5% and 73.2% respondents, respectively, selected competency level 4 or 5 for general procedures and medical stabilization of pediatric patients not using POCUS. There was a statistically significant association between self-reported POCUS milestone competency and provider type ( $P = .04$ ), as well as previous POCUS training ( $P < .001$ ). All respondents without POCUS training selected level 1, and most of those with POCUS training selected level 3 or less (83.2%).

**Conclusions:** This regional multicenter study supports the feasibility of using a milestone-derived tool to self-assess PEM POCUS competency. Respondents reported significantly lower POCUS competency as compared to established PEM ACGME milestones. The majority rate themselves as having lower competency in POCUS despite training. With the increased use of POCUS in PEM, a measure of ultrasound competency for physicians is needed. Further studies could validate the use of this milestone at the national level.

### 2366942 Ultrasound of Hepatic Infections: A Sonographic Pictorial Review

**Vijayanadh Ojili<sup>1</sup>, \* Neeraj Kaur<sup>1</sup>, Arpit Nagar<sup>2</sup>**

<sup>1</sup>Radiology, University of Texas Health Science Center at San Antonio, San Antonio, TX USA; <sup>2</sup>Radiology, Ohio State University Wexner Medical Center, Columbus, OH USA

**Objectives:** To describe the sonographic findings of hepatic infections and correlate these with computed tomographic (CT) findings where available.

**Methods:** A brief review of hepatic infections (including viral hepatitis, liver abscess, hydatid cyst, gas-containing hepatic abscess, mucormycosis, tuberculosis, schistosomiasis, etc) will be presented. The sonographic findings will be described and correlated with CT findings where available. Pertinent management issues including the role of ultrasound-guided interventions will be briefly discussed.

**Results:** Not applicable as this is a pictorial review.

**Conclusions:** The clinical manifestations of hepatic infections are varied and may range from being totally asymptomatic to potentially life-threatening presentations that may require aggressive medical, image-guided, or surgical management. Therefore, it is important for the radiologist to accurately diagnose these conditions in a timely fashion. Ultrasound may be the initial imaging test performed in the diagnostic workup of these patients and will provide a diagnosis in most cases. Ultrasound-guided interventions play an important role in the management of these patients.

### 2371810 Operating Characteristics of Point-of-Care Ultrasound in Identifying Skin and Soft Tissue Abscesses in the Emergency Department

**Sathyaseelan Subramaniam, \* Jacqueline Bober, Jennifer Chao, Shahriar Zehtabchi**

Emergency Medicine, State University of New York Downstate Medical Center/Kings County Hospital Center, Brooklyn, NY USA

**Objectives:** Emergency physicians evaluating skin and soft tissue infections (SSTI) must differentiate abscess from cellulitis, as the former benefits from incision and drainage. Our objective was to determine operating characteristics of point-of-care ultrasound (POCUS) compared to clinical exam in identifying abscesses in emergency department (ED) patients with SSTI features.

**Methods:** We systematically searched the MEDLINE, Web of Science, EMBASE, Cumulative Index to Nursing and Allied Health Literature, and Cochrane Library databases. Trials comparing POCUS with clinical exam to identify skin and soft tissue abscesses were included. Trials that included intraoral abscesses or abscess drainage in the operating room were excluded. Abscess presence was determined by pus drainage. No pus on incision or resolution without pus drainage at follow up proved no abscess. Quality of trials was assessed using Grades of Recommendation, Assessment, Development, and Evaluation criteria. Operating characteristics are reported as sensitivity, specificity, positive likelihood ratio (LR+), and negative likelihood ratio (LR–). Summary measures were calculated by generating a hierarchical summary receiver operating characteristic model (HSROC).

**Results:** Of 3203 references identified, 5 observational studies with 615 patients were included. We rated the quality of 3 trials as low and 2 as very low. The operating characteristics of POCUS and clinical exam are presented Table 1. The POCUS HSROC revealed a sensitivity of 96% (95% confidence interval [CI], 89%–98%), specificity of 79% (95% CI, 71%–86%), LR+ of 4.6 (95% CI, 3.2–6.8), and LR– of 0.06 (95% CI, 0.02–0.2).

**Conclusions:** Existing evidence indicates that POCUS is useful in identifying abscesses in ED patients with SSTI.

Table 1

Study and Intervention	Sensitivity, %	Specificity, %	LR+	LR–
Marin et al, 2013 (pediatric trial)				
Clinical exam	87 (81–91)	71 (62–79)	3.0 (2.3–4.1)	0.2 (0.1–0.3)
Clinical exam + POCUS	88 (82–92)	72 (63–79)	3.1 (2.4–4.1)	0.2 (0.1–0.2)
Iverson et al, 2012 (pediatric trial)				
Clinical exam	90 (75–97)	72 (50–87)	3.2 (1.7–6.1)	0.1 (0.05–0.4)
POCUS	98 (85–100)	68 (46–84)	3.0 (1.7–5.4)	0.04 (0.005–0.3)
Berger et al, 2012 (adult trial)				
Clinical exam	76 (58–89)	83 (36–99)	4.6 (0.8–28)	0.3 (0.1–0.6)
POCUS	97 (83–100)	67 (24–94)	2.9 (0.9–9.0)	0.04 (0.005–0.4)
Sivitz et al, 2010 (pediatric trial)				
Clinical exam	78 (52–93)	81 (63–92)	4.1 (1.9–8.9)	0.3 (0.1–0.7)
POCUS	94 (68–100)	85 (68–94)	6.4 (2.8–14)	0.07 (0.01–0.5)
Squire et al, 2005 (adult trial)				
Clinical exam	86 70 (74–93)	70 (54–82)	2.8 (1.8–4.5)	0.2 (0.1–0.4)
Clinical exam + POCUS	98 (90–100)	88 (74–96)	8.5 (3.7–19)	0.02 (0.003–0.1)

Values in parentheses are 95% CIs.

### 2373506 PULSE: An Objective Programmatic Ultrasound Metric Tool

**Tyler Dschaak,\* Creagh Boulger, Michael Prats, Sara Singhal, Melanie Kennedy, David Bahner**  
Emergency Medicine, Ohio State University, Columbus, OH USA

**Objectives:** The use of ultrasound in emergency medicine (EM) has been rapidly increasing over the past 2 decades and so has the need for bedside ultrasound training. There are varying degrees of maturity of programmatic ultrasound at each educational institution and no current method to objectively score or measure the maturity of an individual program. Assessing the components of a successful ultrasound program may be of use for those seeking training opportunities or lines of research. Quantifying an ultrasound program's maturity may be a method to allow for program strategic planning with regard to operations, recruitment, and quality control.

**Methods:** A metric tool was developed using the 4 areas of an EM training program: administration, research, clinical, and graduate/post-graduate education. Eighteen total sub-branches of these areas were rated on a 0–2 scale (0, absent; 1, present; 2, exemplary) to be able to rapidly and easily calculate an objective score. The scale was used to score 5 different patient care areas internally.

**Results:** The PULSE (programmatic ultrasound evaluator) scale was created as an objective measuring tool to evaluate the 4 areas of an academic ultrasound training program. Using this scale internally, department leaders were able to evaluate the challenges of their programs and develop a 3-year plan to improve areas of weakness.

**Conclusions:** This scale is not meant to replace credentialing or accreditation services but rather serve as a tool to represent the breadth of academic ultrasound within a program. The PULSE scale can be used by program or departmental leadership to determine the strengths and weaknesses of a program to continually make it better. Residents, fellows, and attendings applying to training institutions may use the scale to objectively evaluate the ultrasound footprint of a program and match individual goals with program resources. Further studies will have to determine whether the PULSE can be used for tracking specialty integration with academic ultrasound.

### 2373982 Suspected Small-Bowel Obstruction in the Emergency Department: Accuracy of Point-of-Care Ultrasound

**Mark Gonzales,\* Barbara Stahlman, Brent Becker**

*Emergency Medicine, WellSpan York Hospital, York, PA USA*

**Objectives:** Emergency department (ED) patients with suspected small-bowel obstruction (SBO) are often screened with relatively insensitive abdominal x-rays (AXR). Negative or inconclusive results generally necessitate subsequent evaluation with computed tomography (CT). Use of point-of-care ultrasound (POCUS) as an initial screening test for SBO might reduce the need for CT imaging, decrease exposure to radiation, and expedite patient care. The primary objective of this study was to evaluate the accuracy of POCUS in the diagnosis of SBO.

**Methods:** We conducted a prospective observational study of adult ED patients with suspected SBO. POCUS for SBO was performed by an attending, fellow, or resident physician prior to the completion of AXR or CT. The presence or absence of SBO on POCUS and AXR, as well as specific sonographic findings, were compared to the criterion standard of CT as well as discharge diagnosis. Sensitivity, specificity, and likelihood ratios (LRs) were calculated for both POCUS and AXR.

**Results:** A total of 63 patients have been enrolled to date, of which 39 had POCUS performed by a resident or fellow. POCUS demonstrated an overall sensitivity of 93.3% (95% confidence interval, 77.9%–99.2%), specificity of 51.5% (33.5%–69.2%), +LR of 1.93 (1.34–2.77), and –LR of 0.13 (0.03–0.51) for the diagnosis of SBO. “To-and-fro” peristalsis (90.0% [73.5%–97.9%]) and small-bowel diameter >25 mm (90.0% [73.5%–97.9%]) were the most sensitive findings. The most specific finding was the presence of a transition point (93.9% [79.8%–99.3%]), although this was seen or suspected in only 11 cases. In comparison, AXR was performed in 31 of 63 patients and demonstrated a sensitivity of 71.4% (47.8%–88.7%), specificity of 90.0% (55.5%–99.8%), +LR of 7.14 (1.09–46.76), and –LR of 0.32 (0.16–0.64).

**Conclusions:** On the basis of interim data analysis, POCUS is more sensitive than AXR in the diagnosis of SBO, although less specific. SBO is unlikely in the absence of “to-and-fro” peristalsis or small-bowel diameter >25 mm and likely in the presence of an identifiable transition point.

### 2374957 Peripheral Venous Cannulation Skill Acquisition Using Commercial and Homemade Ultrasound Phantoms

**Dustin Morrow<sup>1</sup>,\* Julia Cupp<sup>2</sup>, Patrick Hunt<sup>1</sup>, Richard Hoppmann<sup>2</sup>**

*<sup>1</sup>Emergency Medicine, <sup>2</sup>School of Medicine, University of South Carolina, Columbia, SC USA; <sup>3</sup>Internal Medicine, Duke University, Durham, NC USA*

**Objectives:** Ultrasound-guided peripheral vascular access decreases use of central lines, increases patient satisfaction, and expedites medical interventions. Providers are trained in this technique using ultrasound phantoms, but effective training strategies are limited, in part, by the high cost of commercial phantoms. This has led to the proliferation of alternative sonographic models for simulation, including food and animal models, which have limitations including perishability and infection control concerns; these early methods were optimized using a commercially

available ballistic-grade gelatin to create a phantom that is low cost, clean, and reusable. The published descriptions of these models have only given qualitative reports of course participant perceptions of their training utility. We now describe a formal study to objectively test the utility of both commercial and homemade models for training novices in the technique of ultrasound-guided peripheral vascular access.

**Methods:** Thirty-six medical students naïve to the technique will be randomized into 3 groups with the following educational interventions: didactics alone (control group); didactics + simulation with commercial phantoms; and didactics + simulation with homemade phantoms. They will be tested by a blinded proctor before and after their educational intervention with 5 timed attempts at intravenous cannulation of a Blue Phantom model. The primary outcome is the change in the number of successful attempts from before to after the educational intervention. Secondary outcomes will include participant perception surveys and time to cannulation. This study has been approved as Institutional Review Board exempt.

**Results:** The study event is scheduled to take place November 13, 2015. Results will be available well in advance of April 2, 2016.

**Conclusions:** We plan to report side-by-side comparisons of the effects of 3 teaching methods—commercial phantoms, homemade phantoms, and didactics alone—on objective skill testing as well as learners' perception of preparedness. This would provide evidence to defend current simulation practices, as well as provide a foundation for future studies and educational initiatives.

#### 2377342 The Hidden Territory of Transvaginal Ultrasound: A Window to Nongynecologic Pathology

Krystal Buchanan,\* Artur Velcani

*Diagnostic Radiology, Yale–New Haven Hospital, New Haven, CT USA*

**Objectives:** While the most common causes of pelvic pain in females are secondary to uterine and ovarian pathology, other structures are in close physical proximity and can precipitate symptoms within the pelvis. These structures include small and large bowel, appendix, urinary bladder, mesenteric fat, lymph nodes, and blood vessels. Although transvaginal ultrasound is essential for evaluation of the uterus and the ovaries, often nongynecologic organs are well visualized and can demonstrate important incidental findings, which in the majority of the cases are acute in nature. The objective of this exhibit is to display illustrative cases of these incidental findings and describe methods to better visualize and analyze these entities so as to improve sensitivity in the acute setting.

**Methods:** In this review, we display cases of the most commonly detected nongynecologic findings on transvaginal ultrasound and outline the sonographic features of each entity, including acute appendicitis, distal ureteral or ureterovesical junction calculi, acute diverticulitis, urinary bladder masses, cystitis, pelvic vein thrombosis, as well as nongynecologic pelvic masses, specifically carcinoid tumors.

**Results:** Sonographic illustrations are presented along with descriptions of techniques to better visualize these entities. This exhibit also discusses the clinical significance of detecting these pathologies and provides management options for guiding referring clinicians.

**Conclusions:** Enhanced awareness of the ability to discover nongynecologic findings on transvaginal ultrasound will heighten observer sensitivity for detection, consequently resulting in more appropriate diagnoses and ultimately more efficient patient care.

#### 2377788 Bedside Ultrasound Evaluation of Diaphragm Thickening

Craig Fryman,\* Sahar Ahmad

*Medicine, Stony Brook University Hospital, Stony Brook, NY USA*

**Objectives:** To characterize and quantify diaphragm behavior, specifically diaphragm thickness (Tdi) with respect to tidal volume (Vt), under various conditions of ventilation and neurologic states.

**Methods:** Using a high-frequency linear array transducer, the right hemidiaphragm is visualized in B-mode at the zone of apposition at a right midaxillary scan plane. Images are acquired at both end-expiration and maximal inspiration. Tdi is measured on still frames. The thickening fraction (TF) is calculated as  $(T_{\max} - T_{\min})/T_{\min}$  for each delivered Vt. Subjects enrolled thus far include those who are mechanically ventilated (n = 4), on pressure support (n = 2), and healthy volunteers (n = 5).

**Results:** Among healthy volunteers, the average Tdi values achieved with maximal inspiration and expiration were 0.46 and 0.17 mm, respectively, correlating with a TF of 1.79. This contrasts in a subject who was evaluated on pressure support following >48 hours of mechanical ventilation (MV), with Tdi inspiration and expiration of 0.13 and 0.09 mm, respectively, correlating with a TF of 0.44. Another subject, with a history of amyotrophic lateral sclerosis, had markedly lower values, with Tdi inspiration and expiration of 0.08 and 0.07 mm, respectively, and a TF of 0.14. Among subjects undergoing positive-pressure ventilation under sedation, there was a trend toward increased TF with respect to increased Vt. The average TF values observed at 400, 600, and 800 mL were 0.34, 0.52, and 0.65, respectively.

**Conclusions:** The diaphragm, a primary muscle of respiration, rapidly atrophies under the influence of MV, and its ability to contract is consequently impaired, as evidenced by a markedly reduced TF. Nevertheless, we observed a positive correlation between Vt and TF, indicating a more robust muscular contraction with larger volumes of delivered air. Notably, these changes may be observed and quantified with the use of bedside ultrasound. Looking forward, we aim to further characterize the effects of MV on the diaphragm in various patient populations. Deeper insight into the physiologic and structural changes that occur in the setting of positive-pressure MV can alter the way we think about respiratory failure, how we teach it, and ultimately how we treat it.

#### 2378430 Creating a Happy Home: Impact of Point-of-Care Ultrasound Services on Physician in-House Satisfaction

Natwalee Kittisarapong<sup>1</sup>, Adam Ash<sup>2</sup>,\* Christopher Raio<sup>3</sup>

*<sup>1</sup>Emergency Medicine, North Shore University Hospital, Manhasset, NY USA; <sup>2</sup>Emergency Medicine, St Joseph Hospital, Astoria, NY USA; <sup>3</sup>Emergency Medicine, Good Samaritan Hospital Medical Center, West Islip, NY USA*

**Objectives:** To determine whether having an in-house point-of-care ultrasound (POCUS) service staffed by ultrasound fellowship-trained physicians improves emergency medicine physician satisfaction.

**Methods:** A 12-question survey regarding satisfaction of POCUS services was distributed among 39 non-ultrasound fellowship-trained physicians at a university hospital with a residency program. Participation was voluntary, and all responses were anonymous.

**Results:** Thirty-five of 39 physicians (90%) replied. Overall, respondents felt that in-house POCUS provided by their fellowship-trained colleagues was performed in a timely fashion, was of high quality, did not need confirmation by a radiology department study, assisted with length of stay, quality of care, and disposition in a timely fashion, and thus improved their workplace satisfaction (Table 1).

**Conclusions:** This study demonstrates a high level of satisfaction with an emergency physician-staffed POCUS team. It also suggests a high level of trust with the sonographic diagnoses made and a decreased need to obtain ultrasound imaging outside the emergency department (ED).



Table 1. Physician Responses to the POCUS Satisfaction Survey

Question	Mode	Mean	CI
1. Ultrasound team performs studies timely	4	3.83	3.59–3.91
2. Trust diagnoses made by ED sonographer	4	3.91	3.78–4.00
3. Studies are more accessible due to POCUS service	4	3.71	3.31–3.83
4. POCUS assists with timely patient disposition	4	3.69	3.49–3.88
5. Overall satisfied with POCUS service	4	3.74	3.40–3.80
6. During residency received training in POCUS	4	3.14	2.83–3.59
7. POCUS service increases job satisfaction	3	3.17	2.83–3.59
8. POCUS assists in providing better clinical care	3	3.34	3.12–3.60
9. POCUS service not available when needed	2	2.00	1.67–2.19
10. POCUS does not assist in providing better care	1	1.37	1.24–1.76
11. POCUS did not decrease length of stay in ED	1	1.49	1.29–1.71
12. POCUS does not decrease length of stay in ED	1	1.77	1.48–2.02

CI indicates confidence interval; 1, strongly disagree; 2, disagree; 3, agree; and 4, strongly agree.

### 2378535 Expectations and Outcomes for the Development of an Ultrasound Curriculum in a Resource-Limited Environment

*Rachel Berkowitz, James Mangan,\* Gabriel Rose, Kyle Cramer, Sebastian Siadecki, Ramona Sunderwirth, Kajal Chhaganlal, Turandot Saul*

*Emergency Medicine, Mount Sinai St Luke's Roosevelt, New York, NY USA*

**Objectives:** Point-of-care ultrasound (US) can be an invaluable tool in resource-limited settings. With increasing recognition of the benefits of global health training, physicians from developed countries are traveling to resource-limited areas for US courses or to establish US programs. The objective of this study was to determine if instructors could design appropriate didactics for Mozambican medical students based on limited knowledge of students' backgrounds and needs, and if surveying novice learners before training would be informative for curriculum development.

**Methods:** Members of the US and global health divisions traveled to Beira, Mozambique, to teach a 3-day course in US for 20 fifth-year medical students. The curriculum included lectures on 12 topics based on experience conducting similar courses and research on regional disease patterns. Instructors and students were surveyed 1 day before the course and 1 day after. The survey collected information about perceptions of local morbidity/mortality and the utility of US modalities, as well as anticipated barriers to adoption and suggested curriculum changes.

**Results:** Overall, instructors accurately identified the diseases perceived by students as most prevalent and responsible for the most mortality; however, they overestimated the rate of obstetric (OB) complications. They also overestimated the extent of trauma and infectious diseases other than human immunodeficiency virus, tuberculosis, and malaria. Regarding the utility of each US modality, instructors rated focused assessment with sonography for trauma (FAST), late OB, and intravenous (IV) access highest before and thoracic and procedural guidance highest after the course. Students rated cardiac and late OB highest before the course. After the course, 40%–50% of students rated cardiac, thoracic, FAST, early OB, and late OB in their top 3.

**Conclusions:** Based on limited research of the local epidemiology and medical system, instructors designed a course for medical students that was well-received; however, when instructors' and students' answers were compared, it was evident that the curriculum could have been improved by several changes: namely, less focus on OB, IV access, and skin/soft tissue evaluation and more emphasis on thoracic and procedural guidance.

### 2378883 Comparison of Subxiphoid Versus Parasternal Long-Axis Views in Focused Assessment With Sonography for Trauma Examinations

*Tanya Bajaj<sup>1</sup>, \*Christopher Raio<sup>2</sup>, Maya Lin<sup>3</sup>, Mathew Nelson<sup>1</sup>, Adam Ash<sup>4</sup>*

*<sup>1</sup>Emergency Medicine, North Shore University Hospital, Manhasset, NY USA; <sup>2</sup>Emergency Medicine, Good Samaritan Hospital, West Islip, NY USA; <sup>3</sup>Emergency Medicine, New York Methodist Hospital, Brooklyn, NY USA; <sup>4</sup>Emergency Medicine, St Joseph Hospital, Bethpage, NY USA*

**Objectives:** To compare the subxiphoid (Sx) and parasternal long-axis (PSL) views during a focused assessment with sonography for trauma (FAST) exam for the following aspects: the image quality of the view, the length of time to obtain the view, the sonographer preference, and the perceived difficulty in obtaining the view. A secondary objective is to determine whether a correlation exists between the quality of the view and the body mass index (BMI) of a patient undergoing a FAST exam.

**Methods:** This is a prospective study in the emergency department at an academic level 1 trauma center. The study included any adult patient undergoing a clinically indicated FAST exam. Pregnant and pediatric patients were excluded. Sonographers were timed in obtaining video clips of the 2 views as part of the FAST exam. They then completed a survey addressing these topics: the sonographer preference of view, relative difficulty in obtaining each view, and quality of images of each view. Two cardiologists, each blinded to the study's objectives, reviewed each video clip and graded the images based on a modified Brightness Mode Quality Ultrasound Imaging Examination Technique (mBQ) scale.

**Results:** Data collection on 35 scans has been completed. The average mBQ score from rater 1 for the Sx view was 9.21 (SD, 6.02), and from rater 2 it was 9.18 (SD, 4.67). The average time was 32 seconds (SD, 17.8 seconds) to obtain the Sx image. For the PSL view, the average mBQ score from rater 1 was 10.48 (SD, 4.88), and from rater 2, it was 9.97 (SD, 4.26). The average time to obtain the view was 27.5 seconds (SD, 15.8 seconds). Linear regression analysis shows a slight trend toward an inverse relationship between mBQ scores and BMI for both the Sx and PSL views, with the trend being more pronounced for the Sx view ( $r = -0.47$  and  $-0.35$  for raters 1 and 2, respectively, for the Sx view and  $r = -0.28$  and  $-0.17$  for raters 1 and 2, respectively, for the PSL view).

**Conclusions:** The preliminary data show that there is no statistical difference between the image quality of both views overall. Experienced sonographers obtain better images using the PSL view. The PSL view may be superior to the subxiphoid view as patient BMI increases.

### 2380777 Implementation of a 4-Year Ultrasound Curriculum in a Medical School

*Jason Mefford,\* Sean Wilson, Shadi Lahham, Mohammed Subeh, J. Christian Fox*

*Emergency Medicine, University of California, Irvine, Orange, CA USA*

**Objectives:** The ability of point-of-care ultrasound (POCUS) to improve patient care, save time, and reduce cost has been well established. Furthermore, the use of POCUS has continued to grow in the practice of medicine globally. As such, the need to integrate ultrasound into medical education is becoming of increasing importance. After implementing a 4-year ultrasound curriculum in a medical school, we sought to assess whether graduating students were able to demonstrate a basic understanding ultrasound physics, machine operation, and image interpretation.

**Methods:** A 4-year ultrasound curriculum was integrated into the medical school educational curriculum, which consisted of teaching basic knowledge of ultrasound physics and machine use (referred to as "knobology") and interpretation of ultrasound images. The curriculum was implemented using both didactics and hands-on experience with live models. On completing the program, fourth-year medical students were

administered an exit exam consisting of 48 questions, divided into 19 knobology and 29 image interpretation questions. The image interpretation questions were further subdivided by anatomic system with 9 cardiac, 2 thoracic, 3 abdominal, 9 vascular, 1 genitourinary, and 5 musculoskeletal questions. Average scores and system-specific scores with corresponding standard deviations were calculated. It was assumed that medical students would have little to no prior ultrasound experience prior to matriculating to medical school.

**Results:** Ninety-five percent ( $n = 84$ ) of fourth-year medical students completed the exam. The overall mean score was 79.5% (SD, 10.2%), with mean scores on the knobology and anatomy portions being 77.1% (SD, 11.0%) and 85.9% (SD, 21.0%), respectively. In the anatomy subdivision, mean scores by system were: cardiac, 95.2% (SD, 18.7%); thoracic, 89.7% (SD, 17.1%); abdominal, 80.0% (SD, 17.6%); vascular, 96.4% (SD, 18.9%); genitourinary, 74.5% (SD, 25.6%); and musculoskeletal, 77.9% (SD, 18.3%).

**Conclusions:** After implementation of a 4-year ultrasound curriculum, medical trainees were able to demonstrate a basic understanding of ultrasound physics, machine use, and image interpretation.

### 2380792 Effect of Prior Concussion on Sonographic Optic Nerve Sheath Diameter Measurement After Undergoing Transient Intracranial Pressure Change

*Ivan Morales<sup>1</sup>, \* Kyle Friez<sup>1</sup>, Richard Gordon<sup>1,2</sup>, Matthew Lyon<sup>1,2</sup>*

<sup>1</sup>Medical College of Georgia, Augusta, GA USA; <sup>2</sup>Emergency Medicine, Georgia Regents University, Augusta, GA USA

**Objectives:** The measurement of the optic nerve sheath diameter (ONSD) by ultrasound is widely recognized as a correlate of intracranial pressure (ICP). Measurement of the ONSD by ultrasound is a quick, noninvasive, and readily available point-of-care tool that can indicate the need for further evaluation of elevated ICP when ONSD dilation is noted. With the increased clinical prevalence of utilizing sonographic ONSD measurements, it is important to recognize additional causes of ONSD dilation. The purpose of this study was to determine the effect of prior concussion on sonographic ONSD measurements after undergoing a transient ICP change via the Valsalva maneuver.

**Methods:** The ONSDs of 10 participants without prior traumatic brain injury (TBI) and 10 participants with a history of mild TBI (concussion) that occurred 1–14 years earlier were measured via ultrasound. The ONSD of each participant was then measured immediately after performing the Valsalva maneuver for 30–45 seconds. The pre- and post-Valsalva ONSD measurements of each group were then compared using a 2-tailed paired  $t$  test.

**Results:** The group without prior TBI showed no significant ONSD dilation with an average increase of 0.03 mm (95% confidence interval [CI],  $-0.03$ – $0.09$  mm;  $P = .3446$ ). The group with prior concussion showed significant ONSD dilation with an average increase of 1.31 mm (95% CI,  $0.89$ – $1.74$  mm;  $P = .0001$ ).

**Conclusions:** These results indicate that transient increases of ICP can interfere with ONSD measurements when individuals have experienced prior concussions. The ability of the ONSD to remain dilated after physiologic processes such as Valsalva suggests that dilation may not be representative of increases in ICP secondary to acute injury in individuals with a prior history of concussion. Additionally, detection of abnormal ONSD dilation after the Valsalva maneuver may serve as a screen for or evidence of prior concussion.

Table 1. Results

	No History of TBI ( $n = 10$ )	History of Mild TBI ( $n = 10$ )
Mean age, y	22.8	25.0
Mean baseline ONSD, mm	$4.28 \pm 0.13$	$4.29 \pm 0.14$
Mean post-Valsalva ONSD, mm	$4.31 \pm 0.12$	$5.60 \pm 0.17$
Mean ONSD dilation, mm	0.03	1.31
	(95% CI, $-0.04$ – $0.09$ ; $P = .3446$ )	(95% CI, $0.89$ – $1.74$ ; $P = .0001$ )

### 2380891 Does Confirmation by Plain-Film Radiography Delay the Use of a Central Venous Catheter When Compared to Ultrasound?

*Samer Assaf<sup>1</sup>, \* Sean Wilson<sup>1</sup>, Chiem Alan<sup>2</sup>, Shadi Lahham<sup>1</sup>, Mohammed Subeh<sup>1</sup>, Samantha Shwe<sup>1</sup>, J. Christian Fox<sup>1</sup>*

<sup>1</sup>Emergency Medicine, University of California, Irvine, Orange, CA USA; <sup>2</sup>Emergency Medicine, University of California, Los Angeles, Sylmar, CA USA

**Objectives:** The current standard practice is to confirm correct placement of central venous catheters of the internal jugular and subclavian veins with plain-film chest radiography (CXR) prior to their use. Previous studies have demonstrated that point-of-care ultrasound (POCUS) may have a potential application to confirm correct placement of these invasive lines. We hypothesized that POCUS would reduce time to confirm correct catheter placement. We therefore sought to compare time to placement confirmation by POCUS to CXR.

**Methods:** This study was a convenience sample of patients in the emergency department and intensive care unit who required central venous catheter placement in the internal jugular or subclavian vein from January 2012 through May 2015. An emergency medicine or internal medicine resident trainee performed the POCUS evaluation after line placement. Correct placement was determined if turbulent flow was visualized in the right atrium on a subxiphoid, parasternal, or apical cardiac view after injecting 5 cc of nonagitated normal saline through the central line. Research assistants recorded time to POCUS, CXR completion, and official radiology CXR interpretation. A 2-sample  $t$  test was used to compare groups.

**Results:** Seventy-eight patients were enrolled; 52% were female, and average body mass index was 29. POCUS had a sensitivity of 84.2% (95% confidence interval [CI],  $74.0\%$ – $91.6\%$ ) and specificity of 100% (95% CI,  $15.8\%$ – $100.0\%$ ) for identifying correct central venous catheter placement. Average times from the start of the procedure to POCUS confirmation, radiography completion, and official radiology read of plain-film radiography were 28, 38, and 449 minutes, respectively. There was a delay of 10 minutes (95% CI,  $0.1$ – $20.2$  minutes;  $P = .06$ ) for CXR completion and 449 minutes (95% CI,  $316.7$ – $525.3$  minutes;  $P < .05$ ) for official radiology CXR interpretation.

**Conclusions:** POCUS may be an effective tool for the early confirmation of central venous catheter placement, especially in instances where there is a delay in obtaining a confirmatory CXR.

### 2381023 A Survey Evaluation of Barriers to Provider Compliance With Point-of-Care Ultrasound Documentation

Sebastian Siadecki<sup>1</sup>,\* Gabriel Rose<sup>1</sup>, Rachel Berkowitz<sup>2</sup>, Turandot Saul<sup>1</sup>

<sup>1</sup>Emergency Medicine, Mount Sinai St Luke's Roosevelt, New York, NY USA; <sup>2</sup>Kaiser Oakland, Oakland, CA USA

**Objectives:** Inadequate point of care ultrasound (POC US) documentation may be detrimental to patient care and lead to substantial lost revenue. The objective of this study was to survey emergency attending physicians on their use of POC US, barriers to documentation, work flow improvements, and incentives. This information may guide improved practices at our institution and may be applicable to other institutions.

**Methods:** A survey was e-mailed to 42 salaried attending physicians at a large academic medical center with an emergency US fellowship and an annual census of 180,000 visits. Fellows, per diem staff, and US faculty were excluded. Responses were anonymous, and data were analyzed with descriptive statistics.

**Results:** Thirty physicians responded to the survey (71.4%). Average experience was 7.86 years; 83.3% of respondents were credentialed in at least 2 POC US applications. Respondents reported that they performed an average of 1.70 POC US exams per shift and documented an average of 56.4% of these exams. The most commonly performed exams were pelvic, focused assessment with sonography for trauma, hepatobiliary, and vascular access. Factors most frequently cited as negatively impacting POC US documentation were “too many other demands on my time,” “requires logging into a separate program,” and “problems with the ultrasound machine.” Suggestions for improvement of the work flow were integration into the existing electronic medical record (EMR), improvements to the US machines, and simplification. When asked which incentives would most increase their compliance with documentation, respondents most frequently chose “financial reward,” “productivity-based bonus structure incorporating relative value units,” and “positive recognition.” All negative reinforcement choices were selected by less than 25% of respondents.

**Conclusions:** The most significant barriers to POC US documentation were time constraints, the existence of a separate computer program for POC US documentation, and problems with the US machines. When establishing a system for POC US documentation, US directors should consider a rapid work flow integrated into the EMR. Positive incentives such as financial rewards are likely to be more effective than penalties for noncompliance.

### 2381269 Ultrasound Confirmation of Gastric Tube Placement: A Novel Method

Vlad Radulescu<sup>1</sup>,\* Sahar Ahmad<sup>2</sup>

<sup>1</sup>Internal Medicine, <sup>2</sup>Pulmonary and Critical Care, Stony Brook University Hospital, Stony Brook, NY USA

**Objectives:** The nasogastric tube (NGT) and orogastric tube (OGT) are essential inpatient tools. We have developed a simple ultrasound (US) protocol for the bedside confirmation of feeding tube placement, which is rapid, is cost-effective, decreases exposure to radiation, requires little experience, and is easy to replicate without adding any substances.

**Methods:** US involved 2 criteria. First, the anterolateral neck was scanned at a high frequency to visualize the gastric tube's characteristic echogenic surface with a posterior anechoic shadow in the esophagus. Then, the right diaphragm location was identified by low-frequency imaging. A distance was measured from the diaphragm to the temporomandibular joint (TMJ) then the TMJ to the nose or mouth (for NGT or OGT, respectively). To be well positioned, their sum would be less than the marking on the tube at the mouth or nose. All statistical analyses were performed by the Biostatistical Consulting Core. Comparisons of US findings were then made to chest x-ray (CXR) findings.

**Results:** Thirty-two subjects were studied. The gastric tubes were confirmed to be in the esophagus and below the diaphragm in 28 cases. In 2 cases, the US scan falsely predicted the tubes to be incorrectly positioned, while in 2 cases, the tubes were not correctly inserted, and the US yielded a true-negative result. The sensitivity of US was 93% (79.5%–98.8%), specificity was 100% (22.4%–100%), positive predictive value was 100% (9.8%–90.2%), and negative predictive value was 50% (89.1%–100%). The length of the gastric tube protruding below the diaphragm estimated by US was within 2.74 cm (SD, 2.34 cm) of the CXR measurement.

**Conclusions:** We have demonstrated a novel and reliable approach for confirming placement of NGT/OGT using US in the hands of a physician with limited training and without prematurely pushing fluid. Our method maintained a strong positive predictive value and accurately estimated the projected length below the diaphragm and should be considered an adjunct or alternative to CXR for NGT/OGT placement.

### 2381993 Ultrasound to Improve Lumbar Puncture Success: A Randomized Controlled Study

Lori Ludeman<sup>1</sup>, Priel Schmalbach<sup>2</sup>,\* Shadi Lahham<sup>1</sup>, Mohammed Subeh<sup>1</sup>, Sean Wilson<sup>1</sup>, Sophia Spann<sup>1</sup>, Jocelyn Chao<sup>1</sup>, Diane Shin<sup>1</sup>, Nadeem Albadaawi<sup>1</sup>, J. Christian Fox<sup>1</sup>

<sup>1</sup>Emergency Medicine, University of California, Irvine, Orange, CA USA; <sup>2</sup>School of Medicine, University of California, Irvine, Irvine, CA USA

**Objectives:** The objective of the study is to compare the success of ultrasound- versus palpation-guided lumbar puncture (LP). LP is a routine procedure performed in the emergency department (ED). It is essential in the diagnoses of meningitis, encephalitis, and subarachnoid hemorrhage, all conditions with a high morbidity and mortality that cannot be missed in the ED. Despite its diagnostic implications, a LP is an invasive process that can be uncomfortable. It was hypothesized that the utility of ultrasound in finding landmarks for LP would decrease the procedural time and number of needle redirections and reinsertions.

**Methods:** This study was conducted at the ED and intensive care unit of a tertiary academic medical center in Orange County, CA. Patients were 18 years or older, scheduled to receive an LP (n = 158), and were randomized into an ultrasound landmark (UL) or a palpation landmark (PL) group. Outcome variables included time from needle insertion to cerebral spinal fluid (CSF) collection and number of needle redirections and reinsertions.

**Results:** The likelihood of a successful procedure was not statistically significant between the UL and PL groups (Fisher exact statistic = 0.112). There was a nonsignificant 28-second reduction in the average procedural time between PL and UL groups (PL = 7.05 [SD = 13.52] vs UL = 6.38 [SD = 7.42] minutes;  $P = .27$ ). The number of needle redirections and reinsertions differed by less than 1 between the two groups ( $P > .10$ ).

**Conclusions:** Although ultrasound is a promising modality for the improvement of LP, the present study found no effect of ultrasound on the success of the LP, time to CSF, needle redirections, and needle reinsertions. Future studies may examine whether ultrasound improves LP success in subpopulations with difficult landmarks such as the obese and individuals with spinal malformations.

### 2382969 Can Emergency Medicine Resident Sonographers Performing Bedside Tracheal Ultrasound Accurately Confirm Endotracheal Tube Placement During an Intubation?

Shadi Lahham, J. Christian Fox, Wynne Breed\*

Emergency, University of California, Irvine, Orange, CA USA

**Objectives:** Primary: Can minimally trained resident physicians detect passage of an endotracheal (ET) tube into the trachea or esophagus in real time? Secondary: Real-time resident read vs remote read by the ultrasound (US) director and comparison of postgraduate year 1



(PGY1) vs PGY2 vs PGY3 to determine role of experience in determining accuracy of tube placement.

**Methods:** A multicenter prospective cohort study using a convenience sample of patients requiring intubation in the emergency department (ED; excluding traumas). Resident physicians were given a 30-minute lecture with hands-on training by the US director from each institution. A waiver of informed consent was granted by the Institutional Review Board due to the emergent nature of the intubations. Patients were considered eligible if they were >18 years requiring emergent intubation in the ED. Exclusion criteria: age <18 years, pregnant, in cervical spine collar, suspected neck injuries/trauma/masses/lesions, active cardiopulmonary resuscitation, and inability to set up the US machine in time. All patients that were unable to be enrolled were logged under the excluded category with corresponding reasons. A linear probe was placed on the neck above the suprasternal notch by the sonographer with the screen facing away from the intubator. A 6-second video clip of ET tube passage was recorded with a postintubation still image and data collection sheet filled out by the sonographer. The intubators recorded their own findings without communication with the sonographer. All normal postintubation protocols were followed. US images and video clips were later reviewed by blinded US directors at each site for ET intubation vs esophageal vs unsure.

**Results:** In order to obtain a 95% confidence interval, we hope to obtain a target goal of 100 patients. Maximum enrollment will be 160, as some patients will need to be excluded if insufficient airway views do not allow an assessment of tube placement. An estimated total of 300 patients will be enrolled between both sites. To date, 41 patients have been enrolled with a sensitivity of 96% and a specificity of 100%.

**Conclusions:** With our results thus far, point-of-care US in the hands of minimally trained EM residents has shown great promise in accurately identifying correct placement of ET tubes during ED intubations.

### 32383284 Lung Ultrasound in the Neurologically Deceased Donor

*Daniel Lebovitz<sup>1,3,4</sup>, Matthew Tabbut<sup>1,2</sup>, Samir Latifi<sup>1,3,4</sup>, Lynn Dezelon<sup>1,2</sup>, Robert Jones<sup>1,2</sup>*

<sup>1</sup>MetroHealth Medical Center, Cleveland, OH USA; <sup>2</sup>Case Western Reserve University School of Medicine, Cleveland, OH USA; <sup>3</sup>Akron Children's Hospital, Akron, OH USA; <sup>4</sup>Lifebanc, Cleveland, OH USA

**Objectives:** Lung transplantation is limited by donor lung availability. Management of donors currently includes serial chest x-ray (CXR), arterial blood gases, fluid management, alveolar recruitment, steroids, naloxone, albuterol, chest physiotherapy, and repositioning. Time delays limit the intervention opportunities and decrease the potential transplantability of organs. Bedside thoracic ultrasound (US) identifies pathology in critically ill patients and is equivalent or superior to CXR or computed tomographic scans. We evaluated thoracic US techniques in identifying abnormal lung pathology in neurologically deceased organ donors and correlated these findings with the current standard approach.

**Methods:** Six neurologically deceased donors were evaluated using bedside lung US. Donors were enrolled sequentially based on availability of experienced physician US operators. Scans were performed using a 3- or 4-zone method. Lungs were evaluated for sliding, A/B profile, and consolidation or pleural fluid. US operators were blinded to donor management data. Individual interpretations of US scans were recorded and compared for interindividual variability. US results were subsequently compared to the standard donor data.

**Results:** Bedside thoracic US interpretations compared well to routine testing during donor management with little interindividual variability and were available immediately. We show that lung US techniques in living intensive care unit patients remain valid in the neurologically deceased organ donor and may be used in real time in donor management. Five of the 6 subjects donated lungs for double lung transplants, with 1 subject not having lungs suitable for transplantation. Lung US identified all findings on CXR and demonstrated additional significant pathology

not reported on CXR. CXR reports took a median of 202 minutes to obtain, while lung US results were available immediately.

**Conclusions:** In our study, bedside lung US was more sensitive in identifying pertinent pathology than CXR. It provides real-time, immediate data. Lung US may play a significant role in donor management, improving efficiency in lung management interventions that may positively impact the numbers of lungs available for transplantation.

### 2383343 A Readily Available, Inexpensive, and Reusable Simulation Model for Teaching Ultrasound-Guided Abscess Identification and Drainage

*Julie Augenstein,\* Hiromi Yoshida*

*Pediatrics, University of Washington, Seattle, WA USA; Emergency Medicine, Seattle Children's Hospital, Seattle, WA USA*

**Objectives:** To create an inexpensive, readily available, and reusable homemade ultrasound phantom that simulates a superficial soft tissue abscess and can be constructed.

**Methods:** We experimented with precooked polenta to create a model that would appear similar to human soft tissue under ultrasound examination. Paintballs were embedded in the polenta and evaluated at different depths until a sonographically satisfactory phantom abscess model was obtained. Various paintball brands and sizes were evaluated to determine the ease of reproducibility.

**Results:** The use of a precooked commercial polenta phantom and commercial paintballs required minimal preparation and closely replicated a superficial soft tissue abscess on ultrasonographic examination. The polenta can be reshaped easily, and the model may be punctured and/or incised multiple times.

**Conclusions:** A homemade high-fidelity simulation phantom that simulates an abscess in superficial soft tissue can be made inexpensively in less than 5 minutes and reused for numerous trainees. This model allows for just-in-time training for procedures such as ultrasound-guided abscess drainage.

### 2383982 Assessment of Proximal Arterial Spectral Doppler Signals in a Model for Acute Compartment Syndrome

*Stefania Carmona<sup>1</sup>, Richard Gordon<sup>2</sup>, Matthew Lyon<sup>2</sup>*

<sup>1</sup>Student, <sup>2</sup>Emergency Medicine, Medical College of Georgia-Augusta University, Augusta, GA USA

**Objectives:** Our study sought to explore the use of spectral Doppler (SD) ultrasound analysis as an early noninvasive screening tool for acute compartment syndrome (ACS).

**Methods:** Our study was a prospective observational trial. Our sample consisted of 14 healthy individuals with no prior history of vascular disease, exercise-induced extremity pain, existing extremity pain, or bleeding diathesis. Participants had bilateral S3 component peak flow velocities of the superior femoral arteries (SFAs) recorded as baseline measurements. A pneumatic device designed to simulate compartment syndrome by exerting pressure exclusively on the anterior compartment of the left leg was used. The device had been previously tested on a cadaveric model. Pressure was increased slowly one pump at a time while monitoring the dorsalis pedis pulse. Late-stage compartment syndrome was defined as the loss of the dorsalis pedis pulse. The peak flow velocity and SD pattern of the SFA at Hunter's canal were recorded, as pressure increased. After 1 minute of rest, the pneumatic tourniquet bladder was pumped to increase pressure a second time. The S3 component peak flow velocity was measured from the SFA at Hunter's canal, to discern abolishment of S3.

**Results:** All participants lost their S3 component of the arterial flow in the SFA. The average number of pumps required to abolish the dorsalis pedis pulse was 4.85. The average number of pumps required to abolish the S3 component of the triphasic arterial flow pattern was 2.75. A 2-tailed, paired *t* test with *P* < .001 confirmed that the abolishment of the S3 component occurs significantly before the loss of the distal pulse

in our ACS model. The abolishment of S3 indicates a loss of normal, low-velocity, low-pressure, late-systolic, antegrade blood flow seen during peripheral artery recoil. We believe this finding is secondary to the increased pressure gradient created by ACS.

**Conclusions:** This study suggests that SD could be used as a noninvasive screening tool to detect early ACS.

**2384129 A Prospective Feasibility Trial of AccuCath 2.25" Blood Control Intravascular Catheter System With a Retractable Coiled Tip Guide Wire Placed in Difficult-Access Patients in the Emergency Department**

**Christopher Raio<sup>1,\*</sup>, Adam Ash<sup>2</sup>, Tanya Bajaj<sup>3</sup>, Natwalee Kittisarapong<sup>3</sup>, Robert Ellspermann<sup>3</sup>, Brendon Stankard<sup>3</sup>, Mathew Nelson<sup>3</sup>, Veena Modayil<sup>1</sup>**

<sup>1</sup>Emergency Medicine, Good Samaritan Hospital Medical Center, West Islip, NY USA; <sup>2</sup>Emergency Medicine, St Joseph Hospital, Bethpage, NY USA; <sup>3</sup>Emergency Medicine, North Shore University Hospital, Manhasset, NY USA

**Objectives:** The primary study objective is to evaluate insertion success rates. Secondary objectives include user preference, patient satisfaction, complications, completion of therapy, and dwell time of the novel AccuCath 2.25" BC catheter system (Food and Drug Administration approved) placed in difficult-access patients.

**Methods:** This is a single-arm feasibility trial evaluating the novel AccuCath 2.25" BC catheter system in a convenience sample of difficult-intravenous access patients defined as at least 2 failed initial attempts or a history of difficult access plus the inability to directly visualize or palpate a target vein. The retractable coiled tip guide wire device is placed under dynamic ultrasound guidance after identification in the emergency department (ED) using a modified Seldinger technique. Patients are followed daily until catheter removal. The following information is recorded for each subject enrolled: catheter device gauge; date, time, and location of each intravenous placement attempt; total number of venipuncture attempts; date and time of successful catheter placement; patient satisfaction at initial placement and on removal using a 5-point Likert scale; and clinician satisfaction at completion of the study using a 5-point Likert scale.

**Results:** Over a 1-month time period 18 patients (>18 years old) have been enrolled and completed the study, with a goal of 120 patients. These patients had an average of 3.5 (95% confidence interval, 3.0–4.0) and median of 3 prior attempts at vascular access prior to AccuCath placement by the ED registered nursing team. Successful access was gained in 100% of the patients, 77% on the 1st attempt and all within 3 attempts. Seventy-seven percent of patients completed therapy, with no moderate or major complications in the other subjects. The average patient satisfaction score on a 5-point Likert scale was highly positive at 4.33.

**Conclusions:** Preliminary results show that the AccuCath 2.25" BC catheter system has excellent success rates in gaining vascular access in an extremely difficult patient population. The device thus far has not led to any significant complications. Patients are also very satisfied with the procedure.

**2384574 A Retrospective Analysis of Ultrasound Usage Rates at Cardiac Arrest Resuscitation Events at a New York Academic Hospital**

**Marc Delaney,\* Sahar Ahmad**

*Stony Brook Medicine, Setauket, NY USA*

**Objectives:** At our institution, ultrasound (US) has recently come into practice for management of cardiac arrest. We aimed to describe the frequency with which leaders of cardiac arrest resuscitation events have chosen to utilize US examinations during their resuscitation efforts. We also aimed to compare these usage rates among different medical service teams with a goal of investigating a correlation between the US usage rate and a likelihood that spontaneous circulation (ROSC) was achieved.

**Methods:** Retrospective patient data were reviewed for date of arrest, medical record number, unit, ROSC achievement, and US usage for each resuscitation event in the internal medicine services from 07/01/14–06/25/15. The exclusion criteria for this initial analysis were any resuscitation events where it was not recorded whether or not US was used in the management (n = 2 events).

**Results:** The usage rate for events lead by internal medicine residents from 07/01/14–06/25/15 overall was 24.8%. Due to a limited data collection period and currently low rates of usage, preliminary data did not have the statistical power to analyze a controlled association between US usage, patient ROSC, and mortality. Our initial unmatched analysis of pooled events shows a positive correlation ( $r^2 = 0.97$ ) between US usage rates and the rates of ROSC in the units reviewed.

**Conclusions:** Our retrospective data review demonstrates a usage rate of 24.8% of US during cardiac arrest resuscitation events. With limited data, our initial analysis of events shows a positive correlation between US usage and rates of ROSC. We intend to disseminate this new information and continue data collection prospectively to further our analysis. We also aim to use these data to encourage more US usage and to fuel interest in an upcoming US-guided resuscitation training program for all internal medicine residents at our institution (Stony Brook University Hospital).

**2384720 Is There a Difference in Radial Artery Localization by Medical Students Using Bedside Ultrasound When Compared to Pulse Palpation?**

**Rachel Berkowitz,\* Gabriel Rose,\* Sebastian Siadecki, Turandot Saul**

*Emergency Medicine, Mount Sinai St Luke's Roosevelt, New York, NY USA*

**Objectives:** Radial artery puncture or cannulation is performed for blood gas analysis, to obtain blood samples in cases of difficult venipuncture, and to monitor intra-arterial blood pressure. Arterial puncture can be challenging, especially in certain patient populations, including the elderly, obese, and those with vascular disease. The procedure has traditionally been performed by simple palpation of the radial pulse, with reported first-attempt success rates ranging from 13.8%–68.6%. While ultrasound is being used with increasing frequency to perform venous access, there are fewer studies on ultrasound for arterial puncture. The objective of this study is to determine whether there is a difference in radial artery localization by medical students using bedside ultrasound when compared to pulse palpation.

**Methods:** Prospective observational study of a convenience sample of medical students and patients. Patients will include those with risk factors for difficult arterial access (age >65 years, wrist circumference >19 cm for men or 16.5 cm for women and/or history of vascular disease). All students will participate in a 1-hour didactic session on ultrasound-guided vascular access. Students will attempt to locate the radial artery by both palpation and ultrasound visualization and mark these sites with an invisible ink pen (only seen with black light). Based on the distance from the ultrasound location, palpation locations will be considered "in" if they fall within 90% of the radius of the radial artery or "out" if they do not.

**Results:** At this time, 11 patients have been enrolled in the study. The projected sample size is 120, including 60 patients with risk factors for difficult radial artery access and 60 control patients. This sample size is powered to achieve confidence intervals of  $\pm 8.9\%$  with a 95% confidence level for the average distance between the two locations.

**Conclusions:** There may be a difference in radial artery localization by medical students using bedside ultrasound when compared to pulse palpation. Ultrasound may assist in radial artery localization in a population with risk factors for difficult arterial access.

### 2384781 A Survey of the Importance of Emergency Ultrasound in Prospective Practice Settings Among Emergency Medicine Residents

**Christopher Mendoza**

*Emergency Medicine, Ultrasound Division, New York Methodist Hospital, Brooklyn, NY USA*

**Objectives:** The goal of this study was to survey emergency medicine (EM) residents about their experience with point-of-care ultrasound (POCUS) and the importance of the accessibility of ultrasound in their future practice settings. This information is important to help set a foundation for the need for ultrasound infrastructure in the community setting. We also aim to highlight the need for POCUS in emergency departments to large EM contract groups and community hospital administrators.

**Methods:** FREIDA, an online residency resource, was referenced to obtain contact information for all current Accreditation Council for Graduated Medical Education–accredited EM residency programs. Each program was asked to distribute a 14-question survey to all residents currently in training. The survey was accessed through surveymonkey.com. All communication was done via e-mail in order to increase compliance. Participation in the survey implied consent.

**Results:** There were 380 responses from various residency programs around the United States. Of the respondents, 36% were postgraduate year 1 (PGY-1), 33% PGY-2, 21% PGY-3, and 5% PGY-4. When asked how often they were using ultrasound, 80% said they were performing at least 1 scan per shift, and of those 80%, 21% said they were performing at least 3 scans per shift. Sixty-five percent of the respondents came from programs that have EM ultrasound fellowships. The residents were asked to score on a scale of 1–5, with 1 being “absolutely will not” and 5 being “very likely”: How likely are you to take a job that does not have POCUS available? How likely are you to take a job that has a machine solely for procedural guidance? The weighted averages of responses were 1.84 and 2.18, respectively. When asked if they felt they would be able to perform quality EM without POCUS, 65% said no, 14% were unsure, and 22% said yes.

**Conclusions:** Residents felt that procedural guidance, echocardiography, early obstetric US, focused assessment with sonography for trauma, and abdominal aortic aneurysms were considered to have the most utility in their future practice. The majority of residents felt that they were very unlikely to take a job at a site that did not have POCUS available. It is clear that current EM residents believe that in order to perform quality EM, POCUS needs to be readily available.

### 2384882 Evaluation of Self-Guided Versus Traditional Ultrasound Education for Third-Year Medical Students

**Margaret Lewis<sup>1</sup>, Lindsey Jannach<sup>1</sup>,\* Celeste Colcord<sup>2</sup>, Lisa Howley<sup>2</sup>, Vivek Tayal<sup>1</sup>**

*<sup>1</sup>Emergency Medicine, <sup>2</sup>Medical Education, Carolinas Medical Center, Charlotte, NC USA*

**Objectives:** Point-of-care ultrasound is increasingly incorporated into undergraduate medical education (UME). Students feel that it is a valuable skill they will use in residency and beyond. Ultrasound education can serve to reinforce anatomy and physiology and enhance problem-solving skills. Limitations exist to implementing ultrasound education in UME. Ultrasound is traditionally taught with a lecture and a hands-on scanning session, requiring machines, instructors, and standardized patients. Monetary constraints for universities as well as time constraints from faculty may be potential limitations. New ultrasound simulators are designed to complement ultrasound education with individual, hands-on training. We aim to compare traditional ultrasound teaching to self-guided learning in the 3rd year of medical school, focusing on free-fluid detection, aorta, cardiac, and thoracic exams. Traditional ultrasound teaching consisted of a lecture with hands-on instruction.

**Methods:** We performed a retrospective review of 3rd-year medical students at the Charlotte Branch of the University of North Carolina School of Medicine. Students previously selected to participate in a longitudinal curriculum received traditional ultrasound education, and students in a block curriculum were invited to participate in self-guided ultrasound education through YouTube videos and SonoSim. Students were assessed by pre- and post-curriculum written tests and hands-on skills assessment.

**Results:** Students with traditional ultrasound education scored 55% and 82% on the pre and post tests. Students with self-guided learning scored 54% and 74%, respectively. On the skills assessment, students with traditional ultrasound education scored an average of 4/5, and those with self-guided learning scored an average of 2.5/5. However, the traditional education cohort had a total of 24 hours of education, and the self-guided cohort averaged 2.6 hours. In the self-guided group, those who spent more time with the simulator had better scores.

**Conclusions:** Students with traditional ultrasound education had better scores but dedicated time for ultrasound education. We do see a role for ultrasound simulators as an adjunct in ultrasound education.

### 2384888 Retrospective Review of Ectopic Pregnancies Diagnosed by Emergency Department Point-of-Care Ultrasound

**Orintia King,\* Tina Dulani, Maya Lin, Andrew Balk,**

**Gerardo Chiricolo**

*Emergency Medicine, New York Methodist Hospital, Brooklyn, NY USA*

**Objectives:** To demonstrate that point-of-care ultrasound (POCUS) reduces time to emergency department (ED) disposition, time to the operating room (OR), and hospital length of stay (LOS) in women with ectopic pregnancies.

**Methods:** A retrospective chart review was performed on patients presenting to the ED from January 1, 2011, to August 1, 2015, who were diagnosed with ectopic pregnancy. Patient charts that utilized comprehensive US were compared to patient charts that used POCUS. The time to disposition, time to the OR, and hospital LOS were reviewed for each patient.

**Results:** From 2011–2015, 66 patients with ectopic pregnancies were reviewed. POCUS was used to make the diagnosis of ectopic pregnancy 41% of the time compared to comprehensive US (65%). Of those patients, 8% received both POCUS and comprehensive US. The majority of ectopic pregnancies were admitted (92%), and less than half of all patients went to the OR (47%). Of the 31 patients who went to the OR, 16 had ectopic pregnancies diagnosed by POCUS, and 2 (13%) had both POCUS and comprehensive US. The ED LOS for patients who went to the OR was 41.43 minutes shorter if ectopic pregnancy was diagnosed by POCUS versus comprehensive US (234.44 vs 275.87 minutes, respectively;  $P = .488$ ). The time to the OR was also shorter in patients who received POCUS (350.44 vs 385.37 minutes for comprehensive US;  $P = .661$ ). The hospital LOS was 1.19 days in patients with ectopic diagnosed by POCUS versus 1.00 day for comprehensive US; however, the POCUS group included 1 patient with a 4-day hospital admission after respiratory failure in the OR.

**Conclusions:** POCUS is often utilized for diagnosing ectopic pregnancies. Although at our institution POCUS is obtained 18% less than comprehensive US, the decision to admit and go to the OR occurs earlier in patients who receive POCUS. Additionally, patients who receive POCUS have shorter ED LOS but have similar hospital LOS compared to those patients who receive comprehensive US. It is reasonable to conclude that POCUS allows for faster decision making and earlier implementation of treatment in patients diagnosed with ectopic pregnancies.



### 2385058 Ultrasound Simulation for Small-Bone Fractures: The Chicken Drumstick Model

*Yuyou Duanmu,\* Christine Lee, Michael Heller, Saadia Akhtar, Jacob Goertz, Nicole Kaban*  
Mount Sinai Beth Israel, New York, NY USA

**Objectives:** In vitro animal models have been used as a teaching aid in ultrasound (US) education, but identifying practical, inexpensive models for the expanding list of bedside applications is a challenge. The purpose of this trial was to evaluate the feasibility of a novel US model consisting of raw chicken drumsticks as an aid in demonstrating the sonographic appearance of fractures in bones approximating the size of adult phalanges and metacarpals.

**Methods:** Twenty emergency medicine residents with no formal training in musculoskeletal US were given a 5-minute presentation on how to use a high-frequency linear probe to examine chicken drumsticks for evidence of fracture. Afterward, each resident scanned 20 drumsticks and recorded their impression of “fracture” or “no fracture.” They then rated the utility of the model on a 5-point Likert scale with 1 indicating “not useful” and 5 indicating “very useful.” A second question utilized a 100-mm visual analog scale (VAS) to assess how much more likely they were to use US to evaluate for small bone fractures in the emergency department after the drumstick experience.  $\chi^2$  analysis was used to compare the Likert scores of simulation usefulness between junior (postgraduate year 1 [PGY1]) and senior (PGY2–3) residents; an unpaired *t* test was used for all other comparisons.

**Results:** The cost of all materials was \$37, including \$24 for 30 chicken drumsticks. Twenty residents scanned 20 drumsticks each, with a mean total scanning time of 12.25 minutes per resident. Accuracy varied widely in this previously unexposed group (mean sensitivity,  $75\% \pm 20\%$ ; mean specificity,  $79\% \pm 18\%$ ), but the model was well received, earning a mean Likert score of 3.85, which was consistent ( $P = .77$ ) between junior and senior residents. There was no correlation between scanning accuracy and enthusiasm for the model ( $R^2 = 0.05$ ). Residents reported that the experience made them more likely to consider high-frequency bone US for clinical use, with a mean VAS of 53 on the 100-mm scale, which did not differ across the PGYs ( $P = .51$ ).

**Conclusions:** The chicken drumstick model described is highly efficient in terms of time and resources for use as an aid in simulated scanning for human small-bone fractures. It appears to be well accepted by those inexperienced in musculoskeletal scanning.

### 2385059 Contrast Extravasation in Emergency Department Patients With Ultrasound-Guided Peripheral Intravenous Catheters

*Jordan Rupp<sup>1</sup>, Robinson Ferre<sup>1,\*</sup>, Jeremy Boyd<sup>1</sup>, Robert Turer<sup>2</sup>, Wesley Self<sup>1</sup>*

<sup>1</sup>Emergency Medicine, Vanderbilt University Medical Center, Nashville, TN USA; <sup>2</sup>Emergency Medicine, University of Michigan, Ann Arbor, MI USA

**Objectives:** Ultrasound-guided peripheral intravenous catheters (USGIVs) are commonly placed in emergency department (ED) patients when traditional attempts have failed. The purpose of this study was to evaluate the prevalence of contrast extravasation and related complications in patients with a USGIV compared to those with traditionally placed peripheral intravenous lines (PIVs).

**Methods:** This was a cross-sectional study of patients  $\geq 18$  years old in an academic urban ED who had intravenous contrast administered for a computed tomographic (CT) scan from 1/2009–4/2014. This study population was generated using administrative billing data of each contrasted CT scan performed in the department. The exposure variable was the type of intravenous (IV) catheter used for contrast administration: USGIV placed by an ED physician versus traditional IV placed without ultrasound. The study outcome was extravascular extravasation of contrast,

which was reported throughout the study period as part of a hospital-wide quality assurance program. Two independent reviewers evaluated each contrast extravasation event to confirm the IV type (traditional PIV vs USGIV) and identify complications that occurred as a result of the extravasation. Extravasation events were classified as having a complication if any of the following occurred: surgical specialty consultation, an otherwise unnecessary admission, or surgical management. The proportion of extravasation events between USGIVs and traditional IVs were compared using the  $\chi^2$  test.

**Results:** There were a total of 49,365 IV contrast boluses for CT scans, including 445 (0.90%) through a USGIV. A total of 120 contrast extravasation events occurred. The prevalence of extravasation was greater with a USGIV (16/445 [3.60%]) compared with a traditionally placed IV (104/48,920 [0.21%];  $P = .002$ ). Thirty-two (26.9%) of the extravasation events resulted in a plastic surgery evaluation, with 1 hospitalization and no cases of operative management.

**Conclusions:** USGIVs have a low infiltration rate for contrasted CT scans. Although the complication rates are similar, the incidence of contrast extravasation events with USGIVs is significantly greater than with traditionally placed peripheral IVs.

### 2385080 Algorithm-Based Automated Inferior Vena Cava Diameter Tracking Correlates With Physician-Performed Measurements

*Christopher Fung<sup>1,2</sup>,\* Barry Belmont<sup>2,3</sup>, Nik Theyyanni<sup>1,2</sup>, Ross Kessler<sup>1,2</sup>, Robert Huang<sup>1,2</sup>, Mohamad Tiba<sup>1,2</sup>, Kevin Ward<sup>1,2</sup>, Albert Shih<sup>2,3,4</sup>*

<sup>1</sup>Emergency Medicine, <sup>2</sup>Michigan Center for Integrative Research in Critical Care, <sup>3</sup>Biomedical Engineering, <sup>4</sup>Mechanical Engineering, University of Michigan, Ann Arbor, MI USA

**Objectives:** Assessment of the inferior vena cava (IVC) with ultrasound is a validated technique in the assessment of hypovolemic patients and can be repeated serially to guide intravenous fluid therapy. However, this technique can be time-consuming and is subject to considerable inter-rater variation. An automated method for tracking IVC variation would be useful and could be consistently applied to serial evaluations of the IVC. Here we describe a novel Kanade-Lucas-Tomasi-based speckle-tracking algorithm and compare its performance to manual image analysis.

**Methods:** A cohort of spontaneously breathing subjects was examined. The IVC was visualized with ultrasound using a subxiphoid approach, in the longitudinal view. Two ultrasound-trained physicians then performed a frame-by-frame analysis of the images and measured the maximum and minimum diameters of the IVC approximately 2 cm caudal to the insertion of the hepatic vein. Continuous automated tracking of the same points in the IVC was also performed using a speckle-tracking algorithm, and IVC diameters were measured throughout the ultrasound clip. The caval index (IVC max diameter – IVC min diameter divided by the IVC max diameter) for each clip was calculated for both the manual and automated techniques and then compared.

**Results:** Ultrasound image clips from 47 patients were analyzed. A wide range of IVC diameter variation was seen with both manual and automated measurements. Mean physician- and algorithm-measured caval indices were 36.4% and 33.5%, respectively, with standard deviations of 29.2% and 26.0%. Intraclass correlation coefficients for the maximum and minimum IVC diameters as well as the caval index were calculated and were 0.897, 0.967, and 0.975, respectively. Additionally, a Bland-Altman analysis indicated that >95% of the manual and automated measurements agreed to within 10%.

**Conclusions:** Automated algorithm-based IVC diameter tracking is highly accurate and correlates well with manual physician-performed image analysis. Continuous real-time tracking of IVC diameter can rapidly calculate a caval index and aid in the assessment of potentially hypovolemic patients.

### 2385093 Acute Breast Complaint at Night: What the Emergency Radiologist Needs to Know

**Abdelmohsen Hussien**

*Radiology, University of Rochester, Rochester, NY USA*

**Objectives:** In the emergency setting, acute breast inflammatory lesions are sometimes a challenge for emergency radiologists; some tend to avoid making a final report and prefer to have the study evaluated the next day by a breast radiologist, concerned about the possibility of inflammatory carcinoma and lacking mammography or other additional imaging. In this presentation, we will emphasize the various types of acute breast lesions seen in the emergency department (ED) setting. We will also focus on an algorithm of management from the radiologist's point of view supported by some clinical facts.

**Methods:** In this presentation, we will discuss a variety of examples of breast lesions seen in the acute setting by ultrasound, including acute mastitis, idiopathic granulomatous mastitis, abscess, and inflammatory carcinoma.

**Results:** Increased ED radiologist awareness of the various types of breast lesions in the ED setting would minimize next-day double reads and would also lead to improved patient management in an emergency setting.

**Conclusions:** Availability of a convenient clear imaging and management algorithm for breast lesions in the acute setting would help optimal decision making by the ED physician and minimize delays in the ED.

### 2385096 Is it Time for Ultrasound Badges of Competency?

**Creagh Boulger, Monica Mikkilineni,\* Tyler Dschaak, Michael Prats, Sara Singhal, Melanie Kennedy, Sarah Greenberger, Sorabh Khandelwal, Andrew King, David Bahner**

*Emergency Medicine, Ohio State University, Columbus, OH USA*

**Objectives:** The use of bedside ultrasound is expanding rapidly, and thus many different providers can use this tool. One specialty where this is especially evident is emergency medicine. In fact, the Accreditation Council for Graduate Medical Education (ACGME) states that "Residents must use ultrasound for the bedside diagnostic evaluation of emergency medical conditions and diagnoses, resuscitation of the acutely ill or injured patient, and procedural guidance." Recently, the ACGME included point-of-care ultrasound into the 23 milestones that serve as a framework for competencies to obtain during residency training. Even with these guidelines, there is still significant variation in training and competency among residents and residencies. The authors describe a "badge system" to clarify specific ultrasound competencies for residents within a department.

**Methods:** Currently, residents spend a minimum of 6 weeks on ultrasound training. As part of this time they complete quizzes, objective structured clinical examinations (OSCEs), and log scans. Using data from the rotation, minimum guidelines for competency equated to achievement levels. This included a log of 25 scans in the desired area, successful completion of an OSCE, an application-specific test, and quality review with no major infractions in the area. On successful completion of all elements, the resident was awarded a badge for this ultrasound competency.

**Results:** There are 55 faculty and over 60 residents. There are 11 indications for emergency medicine. That means there are over 1100 badges that are possible in such a system. This process is still in its inception but has been received positively by residents and faculty.

**Conclusions:** By implementing a badge system to delineate resident competency, residents are able to seek one another out for peer supervision and are able to easily identify which residents are able to assist them with a specific scan. In addition, with over 60 residents and over

40 faculty, this allows the faculty to quickly see which scans the resident is competent in and which others may need more supervision. As more varied operators begin to use this tool, a visible badge system may be useful in a trauma or critical care setting where operators from varied specialties gather.

### 2385124 Intermediate Ultrasound: Going Beyond the Basics of Ultrasound in Medical Student Education

**Nicholas Scoville,\* Antoinette Pusateri, Michael Prats, Creagh Boulger, Tyler Dschaak, Sara Singhal, David Bahner**

*College of Medicine, Ohio State University, Columbus, OH USA*

**Objectives:** Since the trained standardized ultrasound patient (TSUP) program inception in 2006 and an article in 2013, there have been significant modifications, as an entirely new medical school curriculum was implemented in 2012. Adapting ultrasound (US) experiences into the framework of this new 3-part curriculum was necessary to rebrand the experience as part of a competency pathway. The US curriculum progressed from beginner to intermediate to an advanced competency in undergraduate US. The transition to the intermediate US experience (I-US) enhances the student model's role as a learner. The key changes of this revised TSUP program consist in its inclusivity to all 4 years and inclusion in a longitudinal US education competency program.

**Methods:** The I-US program has 2 coordinators. The coordinators e-mail medical students advertising I-US and work with faculty to organize the events of I-US. Interested students (1) attend lectures where various clinical US scans are taught using the I-AIM (indication, acquisition, interpretation, and medical decision making) method, (2) attend open scanning sessions and save 10 complete scans, (3) take a practical and written ultrasound exam, and (4) fulfill 15 TSUP service hours. Fulfilling these requirements constitutes completing the I-US program. Thus, this is an example of how TSUP is easily incorporated into an extracurricular US education program.

**Results:** Since February 1, 2015, over 100 I-US participants have collectively participated in over 500 hours of didactics or scanning sessions as part of the I-US program. These same students have collectively provided almost 900 hours of TSUP modeling service, allowing physicians and students in various departments in the College of Medicine and University Medical Center to become familiar with normal sonographic signatures and practice US technique.

**Conclusions:** Since US is not yet required during medical school, coordinating US experiences in medical education can be challenging. This project describes an adapted US service program previously described into an intermediate part of the path toward an advanced competency. As these changes to the program increase available participation and expand the pathways for students to get involved, the variety of advanced competencies may increase.

### 2385135 Enhancing Quality Assurance Through Examination of Point-of-Care Ultrasound Scans

**Sara Singhal,\* David Bahner, Creagh Boulger, Michael Prats, Tyler Dschaak**

*Emergency Medicine, Ohio State University, Columbus, OH USA*

**Objectives:** With multiple machines, users, and patients, hospitals have adopted quality assurance programs to assess bedside ultrasound exams, as there exists great variability among operators and images saved. Many operators save images without documenting findings, while others document findings without images, necessitating quality assurance. Yet other operators perform ultrasound exams with neither saved images nor documentation. A formal nomenclature system on such scans will educate physicians on best practice measures necessary for increasing physician compliance in using bedside ultrasound. We propose a model for

naming bedside ultrasound exams to identify deficiencies in documentation to enhance patient safety, user compliance, and hospital billing.

**Methods:** We applied this model to the quality assurance of all emergency department–performed bedside ultrasounds at the Ohio State University Wexner Medical Center during the month of August 2015.

**Results:** Of 497 ultrasound exams performed, 393 exams were “true scans,” with both images and a note attached to the medical record, accounting for 79.1% of all scans. An additional 90 scans (18.1%) were “illiterate scans,” where images were saved, but there was no documentation of corresponding findings. Eight scans (1.6%) were “phantom scans,” where no ultrasound images and no documentation were found, but only patient title/“dummy” screens. Six scans (1.2%) were blind scans, where no images were saved, but there was documentation of a scan performed with corresponding “dummy” screens. Limitations include accounting for phantom and blind scans in which there was no “dummy” screen found. We are likely missing a large number of these exams, as we included only those scans with “dummy” screens with no respective ultrasound images. Another limitation includes accounting for educational, or nonbillable, exams, in which the ultrasound was performed for learning purposes or after a comprehensive exam was performed; there is no corresponding documentation to avoid duplicate billing.

**Conclusions:** A nomenclature system as a best practice guideline for bedside ultrasound quality assurance can enhance compliance with documentation, patient safety, compliance, and billing.

#### 2385146 **Ultrasound-Guided Vascular Access Education: Effectiveness of Live Versus Recorded Instruction**

**Patrick Loeffler,\* Matthew Lyon, Richard Gordon**

*Emergency Medicine and Hospitalist Services, Medical College of Georgia, Augusta, GA USA*

**Objectives:** This study examined the effectiveness of recorded lectures versus live lectures in teaching ultrasound-guided vascular access (UGVA).

**Methods:** Participants were divided into a live lecture group and a recorded lecture group. Each group had 60 minutes of instruction on the fundamentals of ultrasound and instruction on both short-axis (SA) and long-axis (LA) approaches for vascular access. Participants then performed SA and LA vascular access on a phantom device without further instruction. Technique was evaluated on time to access (TTA), number of punctures, and errors observed. Techniques that could result in direct patient harm were considered major errors; techniques that could result in reduction in image quality were considered minor errors; and errors in technique that may lead to failure to achieve access in a patient were classified as procedural errors. Participants had to complete the technique in the allotted time, or their results were excluded.

**Results:** There were 66 participants: 35 live lecture participants, and 31 recorded lecture participants. In the live lecture group, the average TTA was 74 seconds in SA ( $n = 34$ ;  $\sigma = 56$ ) with an average of 1.80 punctures, and 41 seconds in LA ( $n = 35$ ;  $\sigma = 50$ ) with an average of 1.17 punctures. One participant's SA results were excluded. In the recorded lecture group the average TTA was 56 seconds in SA ( $n = 30$ ;  $\sigma = 52$ ) with an average of 1.45 punctures, and 51 seconds in LA ( $n = 30$ ;  $\sigma = 70$ ) with an average of 1.26 punctures. One participant's LA, and another participant's SA were excluded. The error rates for the live lecture group were 3% major errors, 43% minor errors, and 29% procedural errors. The error rates for the recorded lecture group were 13% major errors, 55% minor errors, and 23% procedural errors. Two-tailed Student *t* tests showed no statistical significance ( $P > .05$ ) for the differences in averages for any comparison between the live and recorded lecture groups.

**Conclusions:** This study demonstrates that recorded lectures are as effective as live lectures in didactic teaching for UGVA. This suggests that recorded lectures could be as effective as live lectures in teaching other ultrasound skills, which could help overcome the current limitations of traditional instruction.

#### 2385223 **Mastering the “50 Shades of Gray”: Faculty Development Program in Emergency Ultrasonography**

**Kim Chan**

*Emergency Medicine, Singapore General Hospital, Singapore*

**Objectives:** There is an imminent need for a formal emergency ultrasonography (EUS) program in the emergency department (ED). Most EDs have ready access to ultrasound machines, but most clinicians do not save studies performed on patients, which constitute part of the medical documentation. There is also no formal system to assure adequacy and quality of studies performed. Faculty may not be competent or even comfortable in teaching residents in EUS. A lack of formal training is probably the main contributing factor, as most faculty have probably only undergone basic courses in US during their residency training with no subsequent update in EUS. The objective of the program is to train faculty to ensure their proficiency and currency in EUS.

**Methods:** A preprogram survey is issued to get baseline demographics, the confidence level, as well as the training background of each faculty in EUS. Dedicated hands-on sessions for faculty are arranged individually. An immediate postprogram survey is deployed to check on the usefulness of the program. Follow-up surveys at 3 and 6 months are planned, and correlation will be made with image storage and documentations in case notes.

**Results:** Of 22 faculty, 13 underwent the program (59% participation rate), of which 11 surveys were received (84.6% response rate). Ten of 11 (90.9%) had some US foundation, of which 100% were confident with their skills (mean confidence level, 7 [SD, 1.13]; median, 7). None had previously saved their studies, though 9/11 (81.8%) documented findings in the cases notes. After the program, 100% found it useful (mean rating, 9.18 [SD, 0.98]; median rating, 10) and with an increase in their confidence level (mean confidence level, 8.45 [SD, 1.04]; median, 10;  $P = .0037$ ). All 11 faculty reported they will start saving and documenting their studies.

**Conclusions:** There is a definite increase in awareness and confidence level in EUS among the faculty postprogram implementation. Most faculty found a 2-hour session too short. The low participation rate is probably attributed to faculty involvement in other activities (such as vacation, overseas conferences, and other commitments); hence, there is a need for better planning and coordination for future sessions.

#### 2385362 **Follicular Ring Sign in Ovarian Torsion**

**Harinder Singh,\* Maya Lin, Tina Dulani, Christopher Mendoza, Gerardo Chiricolo, Andrew Balk**

*Emergency Medicine, New York Methodist Hospital, Brooklyn, NY USA*

**Objectives:** To determine if the follicular ring sign (FRS) or other ultrasound findings such as the presence of an ovarian cyst/mass or absence of Doppler flow can predict the diagnosis of ovarian torsion.

**Methods:** A retrospective chart review was done for patients diagnosed with ovarian torsion at New York Methodist Hospital from January 1, 2011, to January 1, 2015. Operative reports were reviewed to identify surgically confirmed cases of ovarian torsion. Preoperative pelvic ultrasounds from these cases were examined for the presence of FRS, presence of an ovarian cyst/mass, and presence or absence of Doppler flow. Sixty-three patient charts were reviewed. Forty-three patients were found to have preoperative ultrasounds and surgically confirmed ovarian torsion. In total, 46 scans were reviewed. Thirty-four were radiology scans, performed by an ultrasound technician and read by a radiologist, and 12 were emergency department (ED) scans performed and interpreted by credentialed ED attendings.

**Results:** Of the 46 ultrasounds reviewed, ovarian follicles were seen in 30 scans. The presence of FRS was assessed in these 30 scans (22 radiology and 8 ED). Overall, FRS was found to have sensitivity of 60%, specificity of 83%, positive predictive value (PPV) of 78%, and negative



predictive value (NPV) of 68%. For radiology scans only, FRS had sensitivity of 50%, specificity of 82%, PPV of 73%, and NPV of 62%. For ED scans only, FRS had sensitivity of 88%, specificity of 88%, PPV of 88%, and NPV of 88%. Both ovaries were visualized in 43 of 46 scans. The presence of an ovarian mass or cyst had sensitivity of 84%, specificity of 79%, PPV of 80%, and NPV of 83%. An ovarian mass alone had sensitivity of 28%, specificity of 100%, PPV of 100%, and NPV of 77%. Doppler flow was done in 44 of 46 scans. Nineteen of 44 (43%) had normal arterial and venous Doppler flow; 25/44 (57%) had abnormal or absent arterial flow; 15/44 (34%) had abnormal or absent venous flow; and 15/44 (34%) had abnormal or absent arterial and venous flow.

**Conclusions:** The FRS does not appear to be highly sensitive or specific for the diagnosis of ovarian torsion. The sensitivity and specificity of the ED-focused scan are higher compared to the radiology scans. The presence of an ovarian mass was found to be 100% specific for the diagnosis of ovarian torsion. Forty-three percent of the patients with ovarian torsion had normal arterial and venous blood flow.

### 2385363 Does Point-of-Care Ultrasound Reduce the Emergency Department Length of Stay in the Pregnant Patient Who Requires Pelvic Sonographic Evaluation?

**Kiah Connolly,\* Sean Wilson, Shadi Lahham, Mohammed Subeh, Craig Anderson, J. Christian Fox**

*Emergency Medicine, University of California, Irvine, Orange, CA USA*

**Objectives:** In the emergency department (ED), it is often necessary to perform either a point-of-care ultrasound (POCUS) or radiology department ultrasound (RDUS) as part of the evaluation of a pregnant female patient with a pelvic complaint. The addition of any imaging modality has potential to increase the overall length of stay (LOS). We hypothesized that in patients who required sonographic evaluation, initial evaluation by POCUS would result in a shorter LOS.

**Methods:** This was a subgroup analysis of a prospective randomized control trial of a convenience sample of female patients presenting to the ED between October 2012 and February 2014 for whom the treating clinician deemed sonographic evaluation of the pelvis was indicated. The study was performed at a level 1 trauma center ED with an annual census of 50,000 visits per year and RDUS services readily available 24 hours per day. After informed consent, patients were randomized to POCUS on even days or RDUS on odd days. Time to test completion and overall LOS were obtained. Patients who were <20 weeks pregnant were further analyzed. A 2-sample *t* test and Pearson  $\chi^2$  test were used to compare groups. A linear model with an identity link was found to have best fit for mean LOS.

**Results:** A total of 198 patients were enrolled in the initial study, of which 98 were pregnant. Average age was 29 years old. Forty-one (41.8%) patients were randomized to the POCUS arm, of which 13 (31.7%) subsequently underwent RDUS during the same visit. Patients randomized to RDUS were on average 2.5 years older ( $P = .06$ ) and no more likely to be admitted ( $P = .14$ ) or undergo gynecologic consultation ( $P = .06$ ). Time to completion of RDUS was 65 minutes longer than POCUS (95% confidence interval [CI], 51–73 minutes;  $P < .01$ ). Patients randomized to the RDUS arm experienced a 43-minute longer LOS (95% CI, 21–108 minutes;  $P = .19$ ).

**Conclusions:** While POCUS did not reduce overall LOS, it may have allowed for earlier diagnosis or specialty consultation. POCUS reduced the need for RDUS in up to two-thirds of patients, which may have significant implications in practice environments without 24-hour radiology ultrasound services. Further larger-scale study is needed to confirm these findings.

### 2385382 Performance of an Ultrasound-Guided Fascia Iliaca Block Using a Novel Porcine Neurovascular Bundle Model Compared With a Commercially Available Ultrasound Phantom

**Donald Byars,\* Barry Knapp, Anja Cipi, Turan Kayagil, Matt Jones**

*Emergency Medicine, Eastern Virginia Medical School, Norfolk, VA USA*

**Objectives:** A fascia iliaca block (FIB) is a minimally invasive procedure for analgesia in hip fracture patients. The use of simulation training helps reduce procedure-associated morbidity. Unfortunately, the cost of commercially available models can be a significant barrier to simulation. We prospectively evaluated emergency medicine (EM) provider's performance, degree of satisfaction, and degree of realism when performing ultrasound (US)-guided FIB utilizing a novel porcine model ( $\approx \$20$ ) versus the commercially available Blue Phantom model ( $\approx \$4,000$ ).

**Methods:** This was a prospective observational crossover cohort study. All EM providers who participated in the study completed an FIB procedure education session consisting of physician-taught skill stations for both models and were required to perform an FIB in both models. The primary objective measurements recorded were proper transducer manipulation, needle tip visualization, use of hydrodissection, number of passes of the needle, overall success rate, number of vessel/nerve punctures, and operator's assessment of both degree of satisfaction and degree of realism of both models.

**Results:** Twenty-three EM providers participated in the study. There was no statistically significant difference in success rates, number of needle passes, or vessel/nerve penetrations between the porcine and Blue Phantom models. Operator-assessed degree of satisfaction as rated on a 10-point Likert scale, with 10 being most satisfied, was 8.17 for the porcine model and 6.52 for the Blue Phantom model ( $P = .0019$ ). Operator-assessed degree of realism as rated on a 10-point Likert scale, with 10 being most realistic, was 8.13 for the porcine model and 6.00 for the Blue Phantom model ( $P = .0005$ ).

**Conclusions:** There was no statistical difference in EM physician performance of FIB using the porcine model as compared to the commercially available phantom. The inexpensive porcine model was rated superior to the commercially available model in operator-assessed degree of realism and satisfaction. Inexpensive simulation models like the porcine FIB have the potential to make invasive procedure training more accessible to the provider.

### 2385386 Comparison of the eZono Ultrasound System Compared With a Traditional Technique for Ultrasound-Guided Central Venous Line Placement in a Simulation Model

**Donald Byars,\* Barry Knapp, Zane Shuck, Anja Cipi**

*Emergency Medicine, Eastern Virginia Medical School, Norfolk, VA USA*

**Objectives:** Central venous line (CVL) placement is a common procedure for critically ill and injured patients in the emergency department. Ultrasound guidance has significantly improved the safety of this invasive procedure. There is still, however, significant morbidity associated with CVLs. The use of a needle guidance system such as the eZono may further reduce the patient morbidity associated with this invasive procedure. We prospectively evaluated the performance of emergency medicine (EM) providers in the task of CVL placement utilizing traditional technique (TT) ultrasound versus the eZono system.

**Methods:** This was a prospective observational crossover cohort study. All EM providers who participated in the study completed an eZono education session and a TT CVL review. The education consisted of physician-taught skill stations for both the eZono and TT. Participants were tasked to place a CVL with both the TT and eZono techniques on a phantom. The primary objective measurements recorded were success

rate, time to CVL insertion, number of passes of the needle, number of back wall penetrations, and operator's assessment of ease of use via a Likert scale.

**Results:** Twenty-seven EM providers participated in the study. The success rate for TT was 96% and for eZono was 100% ( $P = .32$ ). The mean number of needle passes required to establish the CVL with TT compared to eZono was 1.52 versus 1.00, respectively ( $P = .0024$ ). The number of back wall penetrations recorded was 13 for TT versus 0 for eZono ( $P < .0001$ ). The time for CVL placement for TT compared to eZono was 68.8 versus 32.7 seconds, respectively ( $P < .0001$ ). Operator-assessed ease of use of TT compared to eZono, from 1 (easy) to 10 (hard), was 3.7 versus 2.5, respectively ( $P = .0007$ ).

**Conclusions:** Though CVL placement success rates were not statistically significant for either technique, the eZono device was superior to TT in all other primary objective measurements. Dynamic needle guidance systems, including the eZono device, have the potential to make CVL placement safer for the patient and easier for the provider.

**2385415 Comparison of the EUCLID Tier 1 Mini-Access System With a Traditional Technique for Ultrasound-Guided Central Venous Line Placement in a Simulation Model**  
**Donald Byars,\* Barry Knapp, Alex Gleason, Travis Wilson**  
*Emergency Medicine, Eastern Virginia Medical School, Norfolk, VA USA*

**Objectives:** Placement of a central venous line (CVL) is a mainstay for critically ill and injured patients. The use of ultrasound has significantly improved the safety of this invasive procedure. There is still, however, significant morbidity associated with CVLs such as inadvertent arterial puncture and pneumothorax. The use of a needle guidance system such as the EUCLID, which is capable of providing precise and accurate needle tip position, may further reduce the patient morbidity associated with this invasive procedure. We prospectively evaluated the performance of emergency medicine (EM) providers in the task of CVL placement utilizing traditional technique (TT) ultrasound versus placement with the EUCLID system.

**Methods:** This was a prospective observational crossover cohort study. All EM providers who participated in the study completed EUCLID education and a TT CVL review. The education consisted of physician-taught skill stations for both the EUCLID and TT. Participants were tasked to place a CVL with both the TT and EUCLID techniques in a phantom. The primary objective measurements recorded were success rate, time to CVL insertion, number of passes of the needle, number of vein back wall penetrations, and operator's assessment of ease of use.

**Results:** Twenty-seven EM providers participated in the study. The success rate for TT was 96% and for EUCLID was 100% ( $P = .32$ ). The mean number of needle passes required to establish the CVL with TT compared to EUCLID was 1.52 versus 1.00, respectively ( $P = .0007$ ). The number of back wall penetrations recorded was 13 for TT versus none for EUCLID ( $P < .0001$ ). Time for CVL placement for TT compared to EUCLID was 68.8 versus 32.1 seconds, respectively ( $P < .0001$ ). Operator-assessed ease of use of TT compared to EUCLID, from 1 (easy) to 10 (hard), was 3.65 versus 2.50, respectively ( $P = .0008$ ).

**Conclusions:** Though CVL placement success rates were not statistically significant for either technique, the EUCLID device was superior to TT in all other primary objective measurements. Needle guidance systems, including the EUCLID device, have the potential to make CVL placement safer for the patient and easier for the provider.

**2385434 An Ultrasound Supplement to Medical Student Education on the Renal System**

**Kristin Hines,\* David Way, Tyler Dschaak, Michael Prats, Sara Singhal, Creagh Boulger, Margret Krebs, David Bahner**  
*Emergency Medicine, Ohio State University, Columbus, OH USA*

**Objectives:** To integrate ultrasound education into a traditional organ systems-based curriculum to enhance understanding of organ anatomy, physiology, and pathophysiology.

**Methods:** Second-year medical students were offered a hands-on ultrasound session to supplement their learning of renal anatomy and pathophysiology. These sessions were preceded by an electronic learning module and a pretest. Participants experienced a 15-minute lecture by a senior medical student, which was followed by small-group proctored scanning time. Proctors were senior students, emergency medicine residents, and faculty. A posttest and satisfaction survey were sent to participants at the end of the session. Pretests and posttests assessed knowledge of renal anatomy and basic renal pathophysiology presented as clinical cases. A paired  $t$  test was used to evaluate test score gains.

**Results:** Seventy-eight of 385 students from 2 medical school classes participated in the program (20.3%); 34 in year 1 and 44 in year 2. Fourteen students from year 1 and 20 from year 2 completed both pretests and posttests (34/78 [43.6%]). Students gained an average of 26 percentage points between pretests and posttests (mean pre = 53.8% [SD = 14.8%]; mean post = 80% [SD = 8.4%];  $t = 11.06$ ;  $df = 33$ ;  $P < .001$ ). Almost all students said the session was an effective learning experience, believed that they better understood renal system anatomy after the session, and would recommend it for future students.

**Conclusions:** Medical students showed a significant gain in tests covering renal system anatomy and pathophysiology after their participation in the supplemental ultrasound session. Students rated the session as beneficial as a supplement to the traditional curriculum. This study demonstrated that introducing ultrasound as a supplement to the traditional organ-based curriculum benefitted student learning of organ anatomy and pathophysiology and may have untested additional benefits.

**2385831 Ultrasound Ground School: A Novel Curriculum for Undergraduate Medical Education**

**Jessica Kotha,\* Creagh Boulger, Tyler Dschaak, Sara Singhal, Michael Prats, David Bahner**  
*College of Medicine, Ohio State University, Columbus, OH USA*

**Objectives:** With the growth of point-of-care ultrasound (US), there is an increased onus on medical schools to provide US education. While US in the preclinical curriculum has been described, there is often a lack of US education during clinical clerkships. The authors aim to describe a novel US curriculum for third-year medical students that has been implemented for students at the Ohio State University College of Medicine (OSUCOM) designed to facilitate understanding of the clinical applications of US.

**Methods:** At OSUCOM, clinical rotations for third-year students are arranged into groups of 2 or 3 rotations, including surgery and obstetrics/gynecology, family medicine and pediatrics, and internal medicine and neurology. Before commencement of the clerkship, students undergo "ground school," where they learn essential clinical skills relevant to each specialty, including US. Before their session, students complete asynchronous didactics. During the ground school experience, students are instructed on physics and knobology and participate in a case-based review of pathology. Students have hands-on practice performing US exams critical to the practice of the specialties in which they will be rotating: obstetrics/gynecology and surgery—pelvic and first-trimester pregnancy US and focused assessment with sonography for trauma; intramuscular and neurology—cardiac, lung, and nerve US; family medicine and pediatrics—aorta and soft tissue US. All students gained further

practice in US-guided procedures and were assessed on their ability to successfully cannulate a vessel using US on a vascular access phantom.

**Results:** To date, over 375 students have participated in the ground school US experience. By utilizing a ground school approach, we have the opportunity to ensure all medical students receive appropriate and standardized training in the use and acquisition of US irrespective of individual clinical assignments.

**Conclusions:** The opportunity for structured US teaching for junior medical students is rare. This curriculum for third-year medical students provides a feasible model for meeting training guidelines without increasing the educational burden on residency programs.

#### 2385845 Tiered Longitudinal Ultrasound Curriculum for Undergraduate Medical Education

*Zachary Goodman<sup>1</sup>,\* Creagh Boulger<sup>2</sup>, Cindy Chang<sup>1</sup>, Suman Gupta<sup>1</sup>, Courtney Tipton<sup>1</sup>, Michael Prats<sup>2</sup>, Tyler Dschaak<sup>2</sup>, Sara Singhal<sup>2</sup>, Michelle Corrado<sup>1</sup>, Nicholas Kelly<sup>1</sup>, David Bahner<sup>2</sup>*

<sup>1</sup>College of Medicine, <sup>2</sup>Emergency Medicine, Ohio State University, Columbus, OH USA

**Objectives:** The Ultrasound Interest Group (USIG) at the Ohio State University College of Medicine (OSUCOM) has consistently been involved in creating opportunities for medical students to acquire ultrasound (US) skills throughout their 4 years in medical school. The USIG decided to survey medical students at OSUCOM to evaluate perceptions of the current US opportunities. Based on the students responses, the USIG Board reorganized the training experiences and developed a tiered curriculum.

**Methods:** A survey was sent to the student body asking for feedback on the current state of the US program at OSUCOM. Students were asked about their level of involvement and participation. Additionally, free-text response boxes were provided for any additional comments. Based on the results of the survey and verbal suggestions from classmates, the USIG Executive Committee held a series of meetings where the US activities were compiled into a cohesive curriculum.

**Results:** A tiered curriculum was created and is separated into Beginner US, Intermediate US, Advanced US, and Honors, each a year in duration. Each program is designed to build sequentially on the previous and take a medical student from naïve to a proficient scanner. On completion of the US course, students will be able to graduate with an advanced competency in US. Beginner US consists of learning US physics, 3 types of scans (focused assessment with sonography for trauma, aorta, and cardiac), and 5–10 trained simulated US modeling hours. Intermediate US adds artifacts, didactics, 3 more scans (pelvic, procedural, and critical care), additional modeling hours, and 10 saved scans. Advanced US emphasizes pathology and learning more advanced scanning specific to the student's medical field of interest. Honors is a year-long elective in the fourth year that includes a US project, a journal club, proctoring hours, and a US portfolio of saved scans.

**Conclusions:** We expect this curricular format to provide logical, consistent, and coherent US training for medical students and to serve as a core for future expansion and refinement of the US program at OSUCOM. This program also allows for easy integration into the framework for students to graduate with advanced competency in US.

#### 2385896 Ultrasound Interest Group Communication Strategies at Ohio State University

*Creagh Boulger, David Bahner, Zachary Goodman,\* Cindy Chang, Nicholas Kelly, Michelle Corrado*

*Emergency Medicine, Ohio State University, Columbus, OH USA*

**Objectives:** The Ultrasound Interest Group (USIG) of Ohio State University has drastically increased in scope and participation over

the past 10 years. One growing problem had been communicating the variety of opportunities available through the interest group to the student body. During the last year of operation, due to the siloed nature of the programs offered, the interest group found a large amount of confusion regarding the role of each program, when it was offered, and who it was targeted to.

**Methods:** To deal with these challenges, a new Executive Board position of public relations chair was created. This chair's responsibility is to coordinate the information sent to the general medical student body to make sure it is complete, organized, and comprehensible. One change enacted by the chair was the institution of a single centralized newsletter to communicate each program, the dates, and any new updates to the student body. We decided on a biweekly newsletter with upcoming events segmented by level of ultrasound training and topics of interest. New items are highlighted in a different-color font, and any changes about the programs will be included. Another change has been the further development of communication through the USIG website. The website's centralized calendar has been improved to include all ultrasound events, times, and locations, and the news section allows instant access to updates. The sidebar has links to descriptions and frequently asked questions about the programs, and an Executive Board contact list was created to allow an easy way to identify the correct contact for a specific problem. Finally, a link to a Google form to help with the logging of hours required by the programs allows hours to be logged at any time from any place, including the student's cell phone.

**Results:** Future studies include measuring the effectiveness and utility of the different communication methods through data analysis and qualitative Likert scale analysis.

**Conclusions:** Proposed benefits of this new communication strategy includes ease of information access, less confusion, a more streamlined interface for students, and decreased e-mail fatigue.

#### 2385904 Enhancing Medical Student Comprehension of Cardiac Anatomy Through Ultrasound

*Creagh Boulger, David Way, David Bahner, Anand Patel, Alex Hatch,\* Ash Panchal, Xi Damrell*

*College of Medicine, Ohio State University, Columbus, OH USA*

**Objectives:** To evaluate whether a 2-hour voluntary cardiac ultrasound course improves medical student knowledge about cardiac anatomy.

**Methods:** First-year medical students volunteered for a 2-hour immersive course on cardiac anatomy and physiology. The course was preceded by an asynchronous online learning module and a pretest. To determine if course success was related to preexisting ability, students also took a test of spatial-perceptual ability (the Revised Vandenberg & Kuse Mental Rotations Test). The course consisted of a 45-minute lecture and an hour of guided hands-on practice. Students were also provided an opportunity to demonstrate their image acquisition skills at an assessment station. At the conclusion of the session, students completed a written posttest and a brief satisfaction survey. Pretests and posttests assessed knowledge of cardiac anatomy and basic image recognition. A 2-way analysis of covariance with 1 repeated measure was used to evaluate test score gains while controlling for preexisting differences in spatial perceptual ability.

**Results:** Two-thirds of the first-year class participated in the immersive course (129/195). All but 9 of the participants completed both the pretest and posttest (n = 120). Course participants gained an average of 35 percentage points from pretest to posttest (mean pre = 46.0% [SD = 24.5%]; mean post = 81.8% [SD = 16.3%];  $F = 40.1$ ;  $df = 1, 117$ ;  $P < .001$ ). The spatial-perceptual ability test score was not a significant covariate (ie, the interaction between the mental-rotations test and pretest-posttest gain was not significant). Almost all of the participants agreed or strongly agreed that the course was an effective supplement to the traditional cur-



riculum (100%), that they better understood cardiac anatomy (97.5%), and that they would recommend the course for future students (100%).

**Conclusions:** First-year medical students rated the immersive cardiac ultrasound experience highly and felt that it was an effective supplement to the traditional curriculum. Participants showed statistically significant gains on a test covering cardiac anatomy and ultrasound images of the heart. Gains were not seemingly related to preexisting spatial-perceptual ability.

#### **2385906 Beginner Ultrasound: An Innovative 1-Year Introductory Course for Medical Students**

*Creagh Boulger, David Bahner, Nicholas Kelly,\* Zachary Goodman, Cindy Chang, Michelle Corrado, Suman Gupta, Courtney Tipton*

*Emergency Medicine, Ohio State University, Columbus, OH USA*

**Objectives:** Numerous ultrasound activities geared toward different years (medical school years 1–4) were created at various times at the Ohio State University College of Medicine. These programs were initially standalone training sessions with a specific end goal and generally were not designed to go with or complement other programs. Beginner Ultrasound will be composed of both required and optional activities designed for students new to ultrasound to get them interested and build the foundations for the subsequent Intermediate Ultrasound course in the next year. Medical students from all 4 years are welcome to participate in Beginner Ultrasound.

**Methods:** Beginner Ultrasound will consist of required lectures on ultrasound physics, which will be followed by a written examination. Students will be taught 3 hands-on sessions built around the Trinity protocol: aorta, cardiac, and focused assessment with sonography for trauma ultrasound scans. Each hands-on session will have both an introductory lecture on the anatomy and an emphasis on hands-on-probe time to build scanning fundamentals. The skills built in these sessions will be tested at the end of the year with both a written and practical test. Additionally, each student will be required to complete 10 hours of trained simulated ultrasound program modeling, where students serve as models for peers and physicians to practice scans. There will be additional optional scans offered by third-year medical students tailored to specific career pathways that students can complete if interested.

**Results:** There was an overwhelming response to the new program, with over 150 students signing up to take part. After the completion of the program, the number of students progressing to Intermediate can be tallied, and the test results from the written and practical tests can be compared to the test results from a precursor program.

**Conclusions:** There was an overwhelming response to the new program, with over 150 students signing up to take part. After the completion of the program, the number of students progressing to Intermediate can be tallied, and the test results from the written and practical tests can be compared to the test results from a precursor program.

#### **2385909 Integrated, Tiered, Self-Guided Ultrasound Scanning**

*Creagh Boulger, David Bahner, Adam Niku\**

*College of Medicine, Ohio State University, Columbus, OH USA*

**Objectives:** Many medical schools have the infrastructure in place for medical students to gain exposure to ultrasound and practice in a dedicated educational space. However, opportunities for independent hands-on learning in ultrasound education are limited. This project was designed as a structured longitudinal model for independent ultrasound learning that could be integrated into an existing medical student ultrasound curriculum. The Ohio State University College of Medicine's new curriculum, Lead. Serve. Inspire. (LSI), is divided into 3 parts. Part I spreads gross anatomy course work over the 2 preclinical years and integrates physiology and pathology, organized by organ system. Part II rep-

resents core clinical clerkships, while Part III focuses on developing advanced competencies. This project was designed to supplement the existing ultrasound learning opportunities in LSI parts I–III.

**Methods:** Preclinical medical students attend 7 optional hands-on ultrasound sessions as part of LSI part I. Additionally, students receive access to 8 system-based self-study ultrasound modules designed to teach image acquisition and sonographic signatures of normal tissue by exploring anatomy. Tasks are tiered according to difficulty. Students save images as part of their digital portfolios, while successful completion will be credited toward completion of an Advanced Competency in Ultrasound in LSI part III.

**Results:** This project has built on the existing ultrasound infrastructure to develop 8 self-guided, flexible modules covering the following systems: musculoskeletal, head and neck, cardiac, aortic, hepatobiliary, renal, endocrine, and reproductive anatomy. Furthermore, the flexible modular design of this project makes it possible to use in various combinations throughout LSI parts I–III.

**Conclusions:** Ultrasound education and competency require a combination of mentorship and opportunity. Structured, self-guided ultrasound scanning represents a unique opportunity to supplement synchronous, directly supervised ultrasound learning. This project provides a possible educational model to increase medical student opportunities for independent, structured, self-directed ultrasound learning that can be integrated with existing educational programs.

#### **2386348 Determination of Right Ventricular Function by Emergency Physician Measurement and Visual Estimation of Tricuspid Annular Plane Systolic Excursion in the Setting of Suspected Pulmonary Embolism**

*James Daley,\* Christopher L. Moore, John Grothberg*

*Emergency Medicine, Yale New Haven Hospital, Milford, CT USA*

**Objectives:** First, to determine whether emergency physicians (EPs) are capable of measuring tricuspid annular plane systolic excursion (TAPSE) with a high degree of agreement between observers in the setting of suspected pulmonary embolism (PE). Second, to determine the capability of the EP to accurately visually estimate TAPSE and classify it in a binary fashion as either normal or abnormal, based on a pre-established definition of abnormal being  $<1.70$  cm.

**Methods:** This was a prospective observational study at an urban teaching emergency department (ED) with  $>100,000$  visits per year. Investigators performed a standardized 4-view echocardiogram and measurement of TAPSE using M-mode on a convenience sample of 36 patients in the ED. Subjects were included if they underwent computed tomography of the chest for suspicion of PE. Exclusion criteria were non-English-speaking patients, prisoners, and wards of the state. TAPSE was measured by 2 blinded investigators in 21 subjects to determine interobserver variability. In 19 subjects, a single investigator visually estimated TAPSE and categorized it as normal or abnormal, prior to measuring TAPSE using M-mode. All investigators were blinded to the subject's diagnosis.

**Results:** The interobserver variability of TAPSE was small. The intraclass correlation coefficient of TAPSE between 2 observers was 0.95 (95% confidence interval, 0.90–0.98;  $P < .001$ ). When TAPSE, as measured by 2 observers, was categorized in a binary fashion as normal or abnormal, the kappa statistic for agreement between independent observers was 1. Regarding a single investigator's ability to visually estimate TAPSE, the phi coefficient as derived by Pearson, which is a measure of association between 2 binary variables, was 1. In all 19 subjects, the EP's binary estimation of TAPSE agreed with its subsequent measurement.

**Conclusions:** EPs are capable of measuring TAPSE with a high degree of agreement between observers and are capable of the accurate visual estimation of TAPSE as normal or abnormal in patients with suspected PE.

## Fetal Echocardiography

### 2374773 Fetal Echocardiographic Findings in Pulmonary Atresia With an Intact Ventricular Septum

**Sangeeta Matang**

*Radiology, Byl Nair Hospital, Mumbai, Maharashtra, India*

**Objectives:** Pulmonary atresia with intact ventricular septum (PAIVS) is a severe cardiac malformation characterized by variable right ventricular (RV) development, an imperforate pulmonary valve, and abnormal connections between the RV and the coronary arteries, known as “ventriculocoronary connections” (VCCs). VCCs are typically found when the RV and tricuspid vein are severely hypoplastic, with hypertrophy of the RV walls. In contrast, VCCs are rare in PAIVS, with a relatively large ventricle capable of supporting more significant tricuspid regurgitation (TR). We describe fetal echocardiographic features of PAIVS in 4 patients.

**Methods:** The study was performed on Philips HD 11 XE and iU22 ultrasound machines using a convex C 2-5 transducer. The size, wall thickness of the RV, tricuspid regurgitation (TR), morphology of the pulmonary valve, presence of a VCC, and presence of retrograde flow in the pulmonary artery (PA) through the ductus were assessed.

**Results:** The gestational age varied from 19 weeks in 3 patients to 26 weeks in 1 patient. Of 4 patients, 2 patients showed typical features of a hypoplastic RV cavity, no TR, a VCC, and reversal of flow through the ductus filling the PA seen in the 3-vessel and trachea view. Two patients showed uncommon features of a massive right atrium, RV enlargement, TR, no VCC, and reversal of flow through the ductus filling the PA. Three patients terminated pregnancy after knowing poor postnatal outcomes. One patient continued until term; the neonate expired a few hours after birth.

**Conclusions:** Fetal echocardiography exposes forms of congenital heart disease not commonly seen postnatally because of the high incidence of perinatal/immediate neonatal period loss. PAIVS is one such condition; especially when there is TR, high mortality in utero is noted. In the absence of TR, the disease is well tolerated in utero. The presence of a VCC is a poor prognostic indicator; hence, its antenatal diagnosis helps in counseling the patients.

### 2384586 The Role of the Left Brachiocephalic Vein in the Prenatal Diagnosis of Total Anomalous Venous Return: A Case Report

**Ghina Mahmoud<sup>1</sup>, \* Jihad Ward<sup>2</sup>, Linda Daou<sup>3</sup>, Reem Abu-Rustum<sup>4</sup>**

*<sup>1</sup>Obstetrics and Gynecology, Lebanese University, Beirut, Lebanon; <sup>2</sup>Obstetrics and Gynecology, Nini Hospital, Tripoli, Lebanon; <sup>3</sup>Pediatric Cardiology, St Joseph University, Beirut, Lebanon; <sup>4</sup>Center for Advanced Fetal Care, Tripoli, Lebanon*

**Objectives:** We present the case of a 31-year-old female, gravida 4, para 1021, with antiphospholipid syndrome, referred at 26 weeks 3 days for a right-sided stomach and abnormal outflow tracts.

**Methods:** Not applicable.

**Results:** On evaluation, there were several findings, including a right-sided stomach, an unbalanced atrioventricular canal, a small left ventricle, a single nonbifurcating large vessel exiting the right ventricle, and total anomalous pulmonary venous return (TAPVR) exemplified by a visible supracardiac collecting vessel. In addition, the left brachiocephalic vein measured 4.5 mm in width (>95th percentile for gestational age), confirming the diagnosis of TAPVR. The diagnosis of heterotaxy with right atrial isomerism and a complex cardiac defect was discussed with the family and confirmed antenatally by pediatric cardiology. The family opted for expectant management and delivered a live-born male at 36 weeks 4 days weighing 2560 g. Postnatally, the findings were confirmed. The family declined surgical intervention due to religious beliefs

and unacceptability of any blood transfusions. The neonate is still alive with central cyanosis.

**Conclusions:** Our case attests to the role of the left brachiocephalic vein in ascertaining the diagnosis of TAPVR. Measuring the width of the left brachiocephalic vein is feasible. Comparing it to the established normogram of Sinkovskaya et al proves helpful in these challenging cases.

## General and Abdominal Ultrasound: Breast

### 2381822 The Diagnostic Performance of Automated Versus Manual Segmentations of Breast Lesions on Ultrasound Images

**Laith Sultan, \* Hui Xiong, Theodore Cary, Susan Schultz, Ghizlane Bouzghar, Chandra Sehgal**

*University of Pennsylvania, Exton, PA USA*

**Objectives:** The shape of a breast lesion provides clues as to whether it is malignant or benign; therefore, a highly accurate delineation of lesion margins on ultrasound images plays an important role in the diagnosis of breast masses. Usually, a user with medical expertise draws the tissue-mass border, defining lesion margins manually. The process, however, is labor intensive and prone to significant variation due to differences in selection criteria. The aim of this study is to compare the diagnostic performance of leak-plugging (LP) automated segmentation to that of manual segmentation of breast masses on ultrasound.

**Methods:** Fifty-two biopsy-proven breast lesion images were analyzed by LP automated and manual segmentation. Three observers manually outlined the boundaries on each lesion. The lesions were also segmented using an automated LP algorithm on the same set of images by the same observers. From each LP segmentation and manually drawn margin, grayscale and morphologic features were extracted and classified as malignant or benign by logistic regression analysis. The performance of LP and manual segmentations was compared by the area under the receiver operating characteristic curves ( $A_z$ ), size of the lesion, and overlap area ( $O_a$ ) between the margins.

**Results:** The  $A_z$  for LP was consistently higher ( $0.910 \pm 0.003$  with a 0.29% coefficient of variation) than the  $A_z$  for the manual tracings ( $0.888 \pm 0.012$  with a 1.3% coefficient of variation). The lesion size from LP segmentation correlated closely with that from manual tracing ( $R^2 = 0.91$ ). The  $O_a$  was higher for LP:  $0.92 \pm 0.01$  and  $0.86 \pm 0.02$  for benign and malignant masses, respectively, compared to  $0.80 \pm 0.01$  and  $0.73 \pm 0.01$  for manual tracings.

**Conclusions:** The diagnostic performance, size measurements, and observer variability for automated LP segmentations were either comparable to or better than those of manual tracings. LP segmentation of breast lesions is a viable alternative to manual tracings for computer-aided analysis of ultrasound images.

### 2385269 A Novel Ultrasound Image-Processing Technique for Detecting Microcalcifications in Surgical Breast Specimens

**Priscilla Machado, \* John Eisenbrey, Maria Stanczak, Barbara Cavanaugh, Lisa Zorn, Flemming Forsberg**

*Radiology, Thomas Jefferson University, Philadelphia, PA USA*

**Objectives:** To evaluate a new commercial image-processing technique (MicroPure; Toshiba America Medical Systems, Tustin, CA) for the identification of breast microcalcifications in surgical specimens compared to fundamental grayscale ultrasound imaging (US), using x-ray imaging of the specimen as the reference standard.

**Methods:** Twenty women, scheduled for surgical excision of 1 or 2 areas with breast calcifications (identified on a prior mammogram), were enrolled in the study. The 22 retrieved surgical specimens underwent a standard US and MicroPure exam using an Aplio XG scanner (Toshiba

America Medical Systems) with a broad-bandwidth linear array. MicroPure combines nonlinear imaging and speckle suppression to mark suspected calcifications as white spots in a blue overlay image. Digital clips of the surgical specimens were acquired using both imaging modes. Independent and blinded readers (2 radiologists and 2 physicists) analyzed 54 standard US and 54 MicroPure digital clips to determine the number of calcifications and scored image quality as well as artifacts on a 10-point scale from 1 (worst) to 10 (best). Qualitative scores were compared using a nonparametric Wilcoxon signed rank test, while the number of breast calcifications was compared with paired *t* tests. The x-ray image of the specimen was analyzed by a radiologist who counted the exact number of microcalcifications (as the reference).

**Results:** For all 4 readers, there were significantly more calcifications seen with MicroPure than with grayscale US (overall means,  $14.0 \pm 11.96$  vs  $3.0 \pm 3.22$  calcifications, respectively) when compared to the exact number of microcalcifications ( $P < .0001$ ). Three readers preferred MicroPure image quality over US ( $P < .009$ ) and vice versa for 1 reader ( $P = .003$ ). Those 3 readers also observed fewer artifacts with MicroPure than with US ( $P < .0001$ ), while the last reader saw no differences ( $P = .58$ ).

**Conclusions:** MicroPure imaging identified more breast microcalcifications than conventional grayscale US when compared to the x-ray image of the surgical specimen. These findings indicate that MicroPure may be used to guide future breast biopsy procedures, but larger studies are needed.

## General and Abdominal Ultrasound: General

### 2362995 Beyond the Basics: Pitfalls in Hepatic Transplant Doppler Sonography

*Marjorie Stein,\* Susan Frank, Jeffrey Roberts, Mordecai Koenigsberg, Fernanda Mazzariol*  
Montefiore Medical Center, New Rochelle, NY USA

**Objectives:** Sonography is the principal modality for assessment of vascular complications following hepatic transplant. Our purpose is to discuss the pitfalls in Doppler sonography of hepatic transplantation and provide strategies for their recognition to avoid misinterpretation.

**Methods:** Educational exhibit based on a retrospective review of the pitfalls in Doppler sonograms of hepatic transplants performed at a single institution over the last 7 years.

**Results:** The following pitfalls will be reviewed: (1) increased velocity of arterial flow due to vascular spasm, tortuosity, perivascular edema, and fluid collections mimicking stenosis; (2) presence of collateral vessels in the setting of chronic hepatic artery thrombosis simulating hepatic artery stenosis; (3) increase in maximum portal vein flow in the early post-transplant period due to reperfusion hemodynamics; (4) temporary dampening of the hepatic venous waveforms in the early post-transplant period commonly due to peritransplant fluid collections or graft edema; (5) The double inferior vena cava (IVC) pattern seen in the piggyback technique of IVC anastomosis most commonly used for partial hepatic transplants.

**Conclusions:** Confident identification of the normal and abnormal Doppler sonographic findings after hepatic transplants and their imaging pitfalls is critical to guide timely management of serious complications, which can lead to graft loss and high mortality.

### 2366186 Liver Imaging Reporting and Data System: Ultrasound Recommendations for Sonographic Screening and Surveillance of Hepatocellular Carcinoma—Initial Proposal

*Aya Kamaya<sup>1</sup>, Sheena Prakash<sup>1</sup>,\* Katherine Maturen<sup>2</sup>, Maryellen Sun<sup>3</sup>, Ashish Wasnik<sup>2</sup>, Nirvikar Dahiya<sup>4</sup>, Tara Morgan<sup>5</sup>, Claude Sirlin<sup>6</sup>, Yuko Kono<sup>6</sup>, R. Brooke Jeffrey<sup>1</sup>, Terry Desser<sup>1</sup>, Alison Harris<sup>7</sup>*

<sup>1</sup>Radiology, Stanford University, Stanford, CA USA; <sup>2</sup>University of Michigan, Ann Arbor, MI USA; <sup>3</sup>Beth Israel Deaconess Medical Center, Boston, MA USA; <sup>4</sup>Mayo Clinic, Scottsdale, AZ USA; <sup>5</sup>University of California, San Francisco, CA USA; <sup>6</sup>University of California, San Diego, CA USA; <sup>7</sup>Vancouver General Hospital, Vancouver, British Columbia, Canada

**Objectives:** Hepatocellular carcinoma (HCC) is a worldwide health care problem and the second most common cause of cancer-related death in the world. The most significant risk factors are cirrhosis from any etiology and hepatitis B virus infection. The goal of HCC screening/surveillance is to detect preclinical HCC at an early stage so that the lesion(s) can be treated with local therapy or so that the patient may still be within guidelines for liver transplantation. Surveillance guidelines have been published by 4 societies, all of which advocate semiannual ultrasound (US), but none of these societies have provided guidance for how US should be performed, interpreted, or reported. Moreover, few studies have addressed the effectiveness of US-based HCC screening/surveillance. There is a need for standardization of sonographic screening and surveillance of HCC, and the intent of this exhibit is to address that need.

**Methods:** The American College of Radiology has convened a working group of experts to develop a US Liver Imaging Reporting and Data System (LI-RADS) for screening/surveillance in patients at risk for developing HCC.

**Results:** Four US LI-RADS categories with corresponding management recommendations have been established: US-0, inadequate; US-1, negative; US-2, subthreshold; and US-3, positive. We illustrate an algorithm that begins with the US examination, poses questions about the quality of the examination and the findings, and places the examination into 1 of the 4 US LI-RADS categories. To complement the US LI-RADS categories, illustrated examples of each category have been collected, and a lexicon of proposed terminology as well as guidelines outlining proper sonographic technique have been developed.

**Conclusions:** This exhibit will present the basis of a US screening/surveillance system in patients at risk for developing HCC. Readers will become familiar with the US LI-RADS categories, algorithm, and management recommendations, with the long-term goal of standardization in US screening/surveillance of HCC.

### 2365108 Common and Uncommon Hepatobiliary and Splenic Infections on Ultrasonography

*Jeffrey Roberts, Marjorie Stein,\* Robert Berkenblit, Melanie Moses, Susan Frank, Mordecai Koenigsberg, Fernanda Mazzariol*

Montefiore Medical Center, New Rochelle, NY USA

**Objectives:** We aim to review the spectrum of sonographic findings of common and uncommon bacterial, fungal and parasitic infections involving the liver, biliary tree, gallbladder, and spleen. We will highlight technical and interpretative pitfalls that should be recognized for accurate diagnosis.

**Methods:** Educational exhibit of the sonographic findings in hepatobiliary and splenic infections.

**Results:** The following are examples of teaching points and strategies that will be discussed and illustrated: (1) tips to recognize bright echoes from clips, sutures, and Surgicel from gas-forming infection and calcifications; (2) the use of color Doppler to help differentiate an abscess from hemorrhage; (3) tips to differentiate bright echoes from gas from calcifica-



tions on B-mode and color Doppler; (4) pearls to differentiate between hepatic and splenic pyogenic infection and fungal (such as candidiasis) and parasitic infections (echinococcus, amebiasis, and schistosomiasis); (5) discussion of sonographic pitfalls and helpful techniques to distinguish gangrenous cholecystitis from a gallbladder neoplasm; (6) Discussion of sonographic pitfalls and helpful techniques to distinguish fungal infections from malignancy in the immunocompromised oncology patient.

**Conclusions:** Knowledge of the ultrasound findings and imaging pitfalls in upper abdominal infections will aid accurate diagnosis to help promptly guide management.

#### **2380576 Regional Vascularity Differences of Thyroid Nodules on Color Doppler Ultrasound**

*Laith Sultan,\* Hui Xiong, Hanna Zafar, Susan Schultz, Jill Langer, Chandra Sehgal*

*University of Pennsylvania, Exton, PA USA*

**Objectives:** Angiogenesis and proliferation of abnormal vessels are often linked with neoplastic cellular proliferation; thus, increased vascularity within thyroid nodules has been associated with malignancy. Although the use of Doppler ultrasound in thyroid imaging has increased, its role in nodule characterization remains limited. The aim in this study is to assess the use of quantitative Doppler vascularity for differentiating thyroid nodules.

**Methods:** Color Doppler images of 100 thyroid nodules were analyzed quantitatively to assess vascularity in 3 concentric regions corresponding to the nodule center, nodule rim, and surrounding parenchyma. Color Doppler pixels displayed in each region were analyzed for vascular fraction area, mean flow velocity index, and mean flow volume index. The diagnostic performance of regional differences was evaluated by randomly dividing the thyroid nodules into training and testing groups. From the training group, the threshold that gave the least percentage error in diagnosis was determined. The threshold was used in the testing group to determine sensitivity and specificity of diagnosis.

**Results:** The vascular fraction area ( $2.8 \pm 5.52$ ) and mean flow volume index ( $0.34 \pm 0.12$ ) of malignant nodules were significantly higher in the center region compared to benign (vascular fraction area,  $14.6 \pm 4.1$ ;  $P = .016$ ; mean flow volume index,  $0.24 \pm 0.08$ ;  $P = .045$ ). The rim regions were highly vascular, but the measurements were not statistically significant ( $P = .086$ ). The mean flow velocity index, on the other hand, was the same for both regions. Of the 3 vascularity metrics studied, the vascular fraction area of the central region was most effective in predicting malignancy, with a sensitivity of  $0.90 \pm 0.05$ , specificity of  $0.88 \pm 0.13$ , positive predictive value of  $0.84 \pm 0.14$ , negative predictive value of  $0.92 \pm 0.03$ , and accuracy of  $0.89 \pm 0.08$ .

**Conclusions:** Of the various quantitative vascularity features studied, the vascular fraction area of the center region was most effective in discriminating benign and malignant thyroid nodules. Future studies using independent data sets will be helpful in validating the proposed methodology, as well as in establishing the potential value of Doppler imaging for clinical applications.

#### **2380938 Hepatic Steatosis and the Potential Use of Hepatic Artery Peak Velocity in Predicting Superimposed Steatohepatitis**

*Hee Park<sup>1</sup>, R. Brooke Jeffrey<sup>2</sup>, Terry Desser<sup>1</sup>, Aya Kamaya<sup>2\*</sup>*

*<sup>1</sup>Radiology, Konkuk University, Seoul, Korea; <sup>2</sup>Radiology, Stanford University, Stanford, CA USA*

**Objectives:** The purpose of this study was to evaluate patients with sonographic evidence of hepatic steatosis and whether there is a correlation between hepatic arterial and portal venous measurements on Doppler ultrasound with potential superimposed steatohepatitis as evidenced by an elevated liver function test (LFT).

**Methods:** A total of 146 patients with sonographically evident hepatic steatosis on grayscale ultrasound were evaluated in this Institu-

tional Review Board–approved retrospective study. Serum bilirubin, aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, and albumin were recorded at the time of the ultrasound. On grayscale ultrasound, the presence of fatty liver was determined based on ultrasound criteria. In all patients, the angle-corrected hepatic arterial velocity (HAv), hepatic arterial resistive index (HARI), and angle-corrected portal vein velocity (PVv) were recorded. Correlation of hepatic arterial and portal venous Doppler values with fatty liver with or without LFT abnormality was tested using binary logistic regression analysis. The diagnostic performance of 100 cm/s for HAv was studied compared to abnormal LFT.

**Results:** HAv showed a statistically significant correlation with the presence of LFT abnormality ( $P = .0018$ ), while HARI ( $P = .6508$ ) and PVv ( $P = .7624$ ) did not correlate with these factors. An HAv threshold of 100 cm/s had a sensitivity, specificity, positive predictive value, and negative predictive value for LFT abnormality of 23.8%, 100%, 100%, and 33.9%, respectively.

**Conclusions:** Elevated HAv statistically significantly correlates with LFT abnormalities in patients with hepatic steatosis and may be a useful imaging biomarker for predicting superimposed steatohepatitis, which has important clinical ramifications.

#### **2384660 Potential Use of Hepatic Artery Peak Velocity in Predicting Liver Function Test Abnormality in Patients With Normal-Appearing Livers**

*Hee Park<sup>1</sup>, R. Brooke Jeffrey<sup>2</sup>, Terry Desser<sup>2</sup>, Aya Kamaya<sup>2\*</sup>*

*<sup>1</sup>Radiology, Konkuk University, Seoul, Korea; <sup>2</sup>Radiology, Stanford University, Stanford, CA USA*

**Objectives:** We sought to evaluate whether hepatic arterial and portal venous measurements in sonographically normal-appearing livers correlated with abnormal liver function tests (LFT).

**Methods:** A total of 544 consecutive patients who underwent abdominal ultrasound with liver Doppler evaluation with concurrently measured LFT values were included in this Institutional Review Board–approved retrospective study. Serum bilirubin, aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, and albumin were recorded at the time of the ultrasound. Patients were excluded from the study if they had evidence of cirrhosis, hepatic steatosis, ascites, biliary ductal dilatation, or hepatomegaly. On Doppler ultrasound, the hepatic arterial velocity (HAv) with angle correction, hepatic arterial resistive index (HARI), and portal vein velocity (PVv) were measured. Correlation of hepatic arterial and portal venous Doppler values was tested in patients with and without LFT abnormalities using binary logistic regression analysis. A threshold of 100 cm/s for HAv was studied for diagnostic performance.

**Results:** A total of 141 patients had sonographically normal livers on grayscale ultrasound. HAv showed a statistically significant correlation with the presence of LFT abnormality ( $P = .0101$ ), while HARI ( $P = .2737$ ) and PVv ( $P = .0506$ ) did not show statistically significant correlation with these factors. An HAv threshold of 100 cm/s had a sensitivity, specificity, positive predictive value, and negative predictive value for LFT abnormality of 16.4%, 97.3%, 84.6%, and 56.3%, respectively.

**Conclusions:** In patients with normal-appearing livers, HAv showed statistically significant correlation with presence of LFT abnormality, while PVv did not show statistically significant correlation with these factors.

#### **2384674 Abdominal and Pelvic Varicosities on Ultrasound**

*Viktoria Paroder,\* Mariya Kobi, Marjorie Stein*

*Radiology, Montefiore Medical Center, Ardsley, NY USA*

**Objectives:** The purpose of this educational exhibit is to familiarize the participant with different types of varicosities encountered in the abdomen and pelvis and their pathophysiologic basis.

**Methods:** Table of Contents/Outline: (1) Pathophysiologic basis of varicosities in the abdomen and pelvis, such as portal hypertension, por-

tal vein thrombosis, pancreatitis, and pelvic congestion syndrome. (2) Review of the normal and variant anatomy of major venous structures evaluated on abdominal and pelvic ultrasound and their appearance on grayscale and Doppler imaging. A short review of proper Doppler technique will be included. (3) Appearance of varicosities on grayscale and Doppler ultrasound, including waveforms and direction of flow. (4) Types of varicosities will include: paraumbilical varices, intrahepatic portosystemic shunts, portal vein varix or aneurysm, superior mesenteric vein varix, gallbladder varices, abdominal wall varices, splenic varices, splenorenal shunt, gastro-splenic shunt, retroperitoneal varices, and pelvic varices.

**Results:** On completion of this educational activity, the participants will be familiar with the pathophysiologic basis of varicosities in the abdomen and pelvis and their appearance on ultrasound, including waveforms and directionality of flow.

**Conclusions:** The spectrum of varicosities that can be detected on abdominal and pelvic ultrasound is broad. The key to their successful detection is knowledge of normal and variant venous anatomy and of the imaging appearance of varicosities on grayscale and Doppler ultrasound. Awareness of pathologic conditions resulting in formation of varicosities is key for their successful detection and subsequently for appropriate patient management.

**2384706 The Usefulness and Safety of 4-Dimensional Ultrasonography With Radiofrequency Therapy for Hepatocellular Carcinoma**  
*Tomomitsu Matono,\* Toshiaki Okamoto, Kenichi Miyoshi, Takaaki Sugihara, Keiko Hoshio, Junichi Okano, Masahiko Koda, Hajime Isomoto*  
*Tottori University, Yonago, Japan*

**Objectives:** Radiofrequency ablation (RFA) therapy under ultrasonography (US) guidance is common therapy for small hepatocellular carcinoma. However, its therapeutic effect and safety depend on accurate needle insertion. Conventional 2D US can only recognize the needle, the target tumor, and the surrounding vessels/organs in the 2D slice images but not in the multiple images, while the 4D US can evaluate them with a multiplanar reconstruction view (A, B, and C planes) using a continuous volume data. The aim of the present study is to compare 2D and 4D US images after needle insertion for RFA and to investigate if they can show the spatial configuration among the needle, the target tumor, and the surrounding vessels/organs.

**Methods:** Thirty-one nodules in 28 patients who underwent RFA underwent 2D and 4D US. An Aplio 500 (Toshiba Medical Systems) was used as the US system for 2D and the 4D probe. We used LeVeen needles for 20 nodules and cool-tip needles for 11 nodules. Before and after the needle insertion for RFA, we semiquantitatively evaluated the visible levels for the needle (1, invisible; 2, partial; 3, all), the target tumor (1, <40%; 2, 40%–80%; 3, >80%), and the surrounding vessels/organs (1, <40%; 2, 40%–80%; 3, >80%) by 2D or by 4D US after needle insertion.

**Results:** 2D and 4D US showed the inserted needles as visible as well as before the needle insertion. The target tumors became invisible in all nodules after the needle insertions in 2D US. The visible levels for the target tumor in 4D US after the needle insertion were better in 28 of 31 nodules than in 2D US and invisible in 3 nodules. The visible levels for the surrounding vessels/organs in 4D US after the needle insertion were better than those in 2D US (4D: 1, 6; 2, 5; 3, 20 nodules; 2D: 1, 11; 2, 20; 3, 0 nodules).

**Conclusions:** 4D US could maintain visualization of the tumor and surrounding vessels/organs after as well as before needle insertion. 4D US was a useful support tool for RFA to exhibit the spatial configuration among the needle, the tumor, and the surrounding vessels/organs.

**2384931 Preliminary Evaluation of a Novel Ultrasonographic Protocol to Detect Schistosomiasis-Associated Intestinal Morbidities in Ukerewe Island, Tanzania**

*Elisa Zhang, Kala Ghooray, Jacqueline Kulwin,\* Samuel Kaplan, Maryte Gyls, Taylor Davis, Jamie Miller, Matthew Gunther, Morgan Kendall, Michael Bernaba, Janice Boughton, J. Christian Fox*

*University of California Irvine School of Medicine, Danville, CA USA*

**Objectives:** The Niamey ultrasonographic protocol is a widely used, World Health Organization–recommended protocol to assess pathologic changes in the liver and urinary system in *Schistosomiasis mansoni* and *hematobium* infection. However, it currently does not include a quantitative scoring system to assess intestinal pathologies known to be associated with schistosomiasis. At the time of publication (1996), it stated that a research priority was to determine the predictive value of ultrasonographic intestinal lesions on schistosomiasis bowel pathology. Here, we create the first quantitative ultrasonographic scoring system for intestinal lesions in schistosomiasis and evaluate the predictive value of this score for recent schistosomiasis infection in Ukerewe Island, Tanzania, a population in which schistosomiasis is endemic.

**Methods:** We used 3 different self-reported measures as indicators of recent schistosomiasis infection: (1) recent or frequent loose and bloody stools, (2) recent schistosomiasis diagnosis, and (3) recent *S mansoni* diagnosis. Using the graded compression technique, subjects' bowels were scored 0 (absent) or 1 (present) on 3 different ultrasonographic bowel measures: free fluid between bowel loops, bowel wall thickness >3 mm, and >2 loops of fluid-filled bowel >2 cm. Scores were summed to give a composite bowel score (CBS; min = 0, max = 3).

**Results:** Forty-three inpatient and outpatient subjects from Ukerewe Hospital were included in our study (mean CBS = 0.4). Mean CBS was significantly higher ( $P = .0453$ , .67;  $n = 21$ ; 2-tailed Student *t* test) in subjects with recent schistosomiasis diagnosis in the last 5 years compared to those without a diagnosis. Mean CBS was not significantly different between subjects with or without bloody loose stools ( $P = .1620$ ;  $n = 6$ ) or between subjects with or without recent *S mansoni* diagnosis in the last 5 years ( $P = .1483$ ;  $n = 9$ ).

**Conclusions:** Our preliminary findings suggest that quantitative ultrasonographic scoring of bowel abnormalities may have a predictive value on recent schistosomiasis infection and should be further evaluated (ie, against fecal diagnoses of schistosomiasis) to determine its predictive value on schistosomiasis intestinal morbidity.

**2384952 Doppler Ultrasound in Patients With Liver Cirrhosis: Correlation of Hepatic Artery and Portal Vein Measurements With a Model for End-Stage Liver Disease Score and Spleen Size**

*Hee Park<sup>1</sup>, R. Brooke Jeffrey<sup>2</sup>, Terry Desser<sup>2</sup>, Aya Kamaya<sup>2\*</sup>*

*<sup>1</sup>Radiology, Konkuk University, Seoul, Korea; <sup>2</sup>Radiology, Stanford University, Stanford, CA USA*

**Objectives:** The purpose of this study was to determine whether hepatic arterial and portal venous Doppler measurements in patients with liver cirrhosis correlate with markers of hepatic decompensation.

**Methods:** Between September 2014 and March 2015, 274 consecutive patients with hepatic cirrhosis who underwent abdominal ultrasound with dedicated hepatic Doppler measurements were studied in this Institutional Review Board–approved retrospective study. Model for End-Stage Liver Disease (MELD) scores were recorded at the time of the ultrasound. On grayscale ultrasound, spleen length was measured, and the presence of ascites was recorded. The angle-corrected hepatic arterial velocity (HAv), hepatic arterial resistive index (HARI), and portal vein velocity with angle correction (PVV) were measured on spectral

Doppler interrogation. Correlation of hepatic arterial and portal venous Doppler values with the MELD score, spleen size, and presence of ascites was tested using Pearson correlation or binary logistic regression analysis.

**Results:** HAV showed a statistically significant correlation with the MELD score ( $P = .0001$ ), spleen size ( $P = .027$ ), and presence of ascites ( $P = .0001$ ), while HARI ( $P = .421$ ,  $.85$ , and  $.577$ , respectively) and PVV ( $P = .327$ ,  $.48$ , and  $.62$ , respectively) did not correlate with any of these factors.

**Conclusions:** Elevated HAV statistically significantly correlates with a high MELD score, decompensated liver cirrhosis, and splenomegaly in patients with liver cirrhosis and may be a useful imaging biomarker in evaluation of patients with cirrhosis.

## General and Abdominal Ultrasound: Urinary Tract

### 2362794 Common and Uncommon Genitourinary Infections on Ultrasonography

**Zina Ricci, Marjorie Stein,\* Jeffrey Roberts, Robert Berkenblit, Melanie Moses, Susan Frank, Mordecai Koenigsberg, Fernanda Mazzariol**

*Montefiore Medical Center; New Rochelle, NY USA*

**Objectives:** Ultrasound is often used for the initial workup of flank pain from presumed stone disease and urinary tract infection, and it is the primary modality for imaging of the scrotum. We aim to review the spectrum of sonographic findings of common and uncommon genitourinary (GU) bacterial, fungal, and parasitic infections involving the kidneys, bladder, and scrotum. We will highlight technical and interpretative pitfalls that should be recognized for accurate diagnosis.

**Methods:** Retrospective review of the sonographic findings in common and uncommon GU infections in our institution in the last 20 years.

**Results:** The following are examples of teaching points and strategies that will be discussed and illustrated: (1) proper adjustment of B-mode gain to demonstrate low-level echoes in inflammatory collections and to differentiate between infection and hemorrhage; (2) the use of color Doppler to help diagnose focal nephritis; (3) tips to recognize gas in tissues and to distinguish gas from small calcifications on B-mode and color Doppler; (4) pearls to differentiate between orchitis and torsion/detorsion; (5) the sonographic difficulty distinguishing an atypical abscess from an infiltrative tumor.

**Conclusions:** Knowledge of the ultrasound findings and imaging pitfalls in GU infections will aid accurate diagnosis to help promptly guide management.

### 2366167 Missing Diagnosis and Sonographic Characteristics of Horseshoe Kidney

**Kevin Gueng<sup>1</sup>,\* Clayton Chen<sup>1</sup>, San-Kan Lee<sup>2</sup>**

*<sup>1</sup>Radiology, Taichung Veterans General Hospital, Taichung, Taiwan; <sup>2</sup>Radiology, Tungs' Taichung Metro-Harbor Hospital, Taichung, Taiwan*

**Objectives:** To evaluate the missing diagnosis and the characteristics of the horseshoe kidney on sonography.

**Methods:** From January 2003 through October 2015, 54 consecutive patients with horseshoe kidney had been proven by computed tomographic (CT) scans. All cases received sonographic examinations before or after CT scans. Retrospective analyses of the sonographic findings and reports of all patients were performed by 2 experienced sonologists.

**Results:** Tracing reports of sonography, there were 9 cases (17%) that were missed by initial sonography just before or after CT scans. Reliably sonographic features of horseshoe kidney included an isthmus anterior to the aorta in 47 cases (87%), a tapering lower end in 28 cases (52%), and a bent contour and overlapping vertebra in 39 cases (72%),

but malrotation and an altered axis of kidney were difficult to assess by sonography.

**Conclusions:** To prevent missing diagnosis of horseshoe kidney, searching the isthmus and especially the longitudinal view, tapering lower end, bent contour, and overlapping vertebra, are important features during ultrasound scanning.

### 2384923 Renal Arteriovenous Malformation as a Cause of Hematuria: An Uncommon Cause of a Common Problem

**Sabrina Mahboob**

*Radiology, Winthrop University Hospital, Mineola, NY USA*

**Objectives:** Our objective is to describe renal arteriovenous malformation (AVM) and how it can present with hematuria. The importance of recognizing this entity as a cause of hematuria beyond the more common causes of stones, urinary tract infections, and tumors will be highlighted.

**Methods:** Our methods included a MEDLINE and PubMed search on "renal arteriovenous malformation," "uncommon causes of hematuria," and "congenital renal AVM." Relevant literature and recent guidelines on the management of renal AVM were reviewed.

**Results:** We present the case of a young male who presented with hematuria and anemia. As part of an initial workup, renal ultrasound revealed a cystic structure near the renal hilum that demonstrated a mosaic pattern and aliasing on Doppler, related to the turbulent flow. Tortuous vessels were also identified adjacently. As the patient had no history of prior renal intervention, a diagnosis of congenital renal AVM was made. In addition to detailed sonographic findings, further workup and management options will be discussed.

**Conclusions:** Gross hematuria and flank pain are among the most frequent complaints seen in urology outpatient clinics and emergency departments worldwide. Common causes of gross hematuria include urinary tract infections, urolithiasis, and neoplasms of the genitourinary tract. Renal AVM is among the rare causes of gross hematuria. The consideration of this diagnosis early during diagnostic workup can be paramount to management of this condition, especially with its potential for rapid clinical deterioration. Other more infrequent presentations may include symptoms or signs of congestive heart failure from high-output fistulas or hypotension from massive hematuria.

## Gynecologic Ultrasound

### 2348973 Ultrasound Appearance of the Uterus After Endometrial Ablation

**Melanie Moses**

*Radiology, Montefiore Medical Center, Mount Vernon, NY USA*

**Objectives:** Endometrial ablation is a relatively new procedure. We aim to review the various sonographic findings in the uterus after endometrial ablation and provide correlation with computed tomography (CT) and magnetic resonance imaging (MRI), when available. The differential diagnosis of the appearance of the endometrium will also be highlighted.

**Methods:** Retrospective review of the sonographic appearance of the uterus and complications after endometrial ablation in a single institution over 4 years.

**Results:** The teaching points to be discussed and illustrated are as follows: (1) Explanation of the purpose and technique of endometrial ablation. (2) Discussion and demonstration of possible outcomes related to the procedure, such as air in the endometrial cavity, hematometra, and residual islands of endometrial tissue. (3) Discussion of the postablation endometrial thickness measurements in patients without hematometra. (4) Recognition of the irregularity of the endometrial echo in patients with an almost normal-appearing endometrium. (5) Establishing the unusual ultrasound appearance of hematometra in patients with endometrial abla-



tion by comparing it to the appearance of hematometra secondary to other causes. (6) Determining guidelines for recognizing the appearance of endometrial ablation on CT and MRI as well as ultrasound.

**Conclusions:** Recognizing the potential appearances of the endometrial cavity after endometrial ablation and knowledge of possible complications aids in accurate diagnosis and proper patient management.

**2362790 Essure Confirmation Test With Transvaginal Ultrasound**  
**Viviane Connor<sup>1</sup>,\* Michel Vleugels<sup>2</sup>, Keith Bangerter<sup>3</sup>,  
 Jeffrey Goldstein<sup>3</sup>, Ru-fong Cheng<sup>3</sup>**

<sup>1</sup>Cleveland Clinic Florida, West Palm Beach, FL USA;

<sup>2</sup>Rivierenland Hospital, Tiel, the Netherlands; <sup>3</sup>Bayer HealthCare, Whippany, NJ USA

**Objectives:** Essure is indicated for women who desire permanent birth control via bilateral tubal occlusion. The efficacy of Essure when a new confirmation testing algorithm with transvaginal ultrasound (TVU), modified hysterosalpingogram (HSG), or both was used 3 months postplacement was assessed in a phase 4 study.

**Methods:** Women aged 21–44 years without contraindications and scheduled for Essure placement were eligible. Per the TVU/HSG confirmation testing algorithm, TVU was an option for confirmation testing 3 months postplacement if the placement procedure was not difficult and the postoperative course was uneventful, according to the defined protocol. Coprimary end points were the 1-year pregnancy rate and Essure reliance rate. Safety evaluation was based on adverse events (AEs).

**Results:** Essure placement was attempted in 597 women (intent-to-treat [ITT]; mean age, 34.4 years), with bilateral placement achieved in 582; 547 were told to rely on Essure. In these 547, the 1-year pregnancy rate was 0.67% (95% confidence interval [CI], 0.16%–1.53%). The ITT reliance rate was 91.6% (95% CI, 89.2%–93.6%). Four women became pregnant after being told to rely on Essure; all 4 were told to rely based on TVU confirmation testing alone, read as optimal insert location. Postpregnancy follow-up and root cause analysis revealed 2 perforations and 2 unsatisfactory insert locations. Of the 547 told to rely, 85.9% had TVU confirmation testing alone (Table 1); test usage patterns for reliance were similar in and outside the US. TVUs were performed mostly by physicians in Spain/Canada and by physicians or sonographers in the US/Netherlands. The range of endovaginal probe center frequencies (arithmetic average) used was 5.8–6.5 MHz. Most AEs were mild and unrelated to Essure.

**Conclusions:** Essure is an effective method of permanent sterilization when the TVU/HSG confirmation testing algorithm is used; 85.9% of women were able to rely on Essure based on TVU confirmation testing alone.

Table 1

Confirmation Test	Test Performed, n/N (%) <sup>a</sup>	Test Used in Those Told to Rely, n/N (%) <sup>b</sup>	Test Used in Those Told Not to Rely, n/N (%) <sup>c</sup>
TVU alone	474/582 (81.4)	470/547 (85.9)	4/35 (11.4)
TVU followed by HSG	53/582 (9.1) <sup>d</sup>	47/547 (8.6)	6/35 (17.1)
HSG alone	32/582 (5.5) <sup>e</sup>	30/547 (5.5)	2/35 (5.7)
None	23/582 (4.0) <sup>f</sup>	0	23/35 (65.7)

<sup>a</sup>Denominator based on number of participants with bilateral placement (N = 582).

<sup>b</sup>Denominator based on number of participants told to rely on Essure (N = 547).

<sup>c</sup>Denominator based on number of participants told not to rely on Essure (N = 35).

<sup>d</sup>HSG performed due to abnormal TVU findings or at the physician's discretion.

<sup>e</sup>Proceeded directly to HSG per the TVU/HSG algorithm.

<sup>f</sup>Lost to follow-up, voluntary withdrawal, excessive length of time since procedure, or no longer at risk for pregnancy.

**2374285 The Use of Transperineal 3-Dimensional Pelvic Ultrasound in the Evaluation of Anterior Vaginal Wall Cysts**

**Lauren Scott,\* Peter Takacs, Kindra Larson, Alfred Abuhamad**  
 Obstetrics and Gynecology, Eastern Virginia Medical School, Norfolk, VA USA

**Objectives:** The objective of this study was to report on our experience with transperineal 3D pelvic ultrasound (TPU) in the evaluation of anterior vaginal wall cysts.

**Methods:** A retrospective review of the health records of all women referred to our division of urogynecology for TPU with vaginal fullness or a vaginal “cyst-like” structure (inclusion criteria) from 12/2013 to 7/2015 was performed. Ultrasound findings such as size, complexity, vascularity, and connection to urethra were evaluated. Maternal demographics along with patient outcomes were reviewed.

**Results:** During the study period, a total of 54 patients met the inclusion criteria. The mean age was 51.3 years (range, 24–84 years), and median parity was 2 (0–6). Thirty-nine of the 54 patients (72%) had physical exam findings of fullness (6/39) or anterior vaginal wall cysts (33/39), while only 35% (19/54) had cysts noted on TPU. Of the cysts seen on ultrasound, the majority were simple (79% [15/19]). Only 2 were vascular in appearance. Of the 19 with cysts identified on ultrasound, 5 elected to have surgery, 5 elected to have observation, 5 were lost to follow-up, 1 was pregnant, and 1 is awaiting surgery. The most common cysts were inclusion cysts (60%). There was one diverticulum. One Gartner's duct cyst was removed. The ultrasound impression correlated with operating room findings and pathology 100% of the time.

**Conclusions:** TPU is a useful tool in evaluating anterior wall cysts.

**2374872 Cervical Ectopic Pregnancy: Case Series of 5 Cases**

**Alpana Joshi**

Radiology, Shobha Diagnostic Center, Mumbai, Maharashtra, India

**Objectives:** A “cervical pregnancy” is an ectopic pregnancy that has implanted in the uterine endocervix. It typically aborts within the first trimester; however, if it is implanted closer to the uterine cavity, so-called cervico-isthmic pregnancy, it may continue longer. Placental removal in a cervical pregnancy may result in major hemorrhage. It can be confused with miscarriage as abortion in progress, with the sac passing through the cervix. Hence, it is important to diagnose it correctly. We discuss the diagnostic features on ultrasound, importance of color Doppler in correct diagnosis, and role of ultrasound in follow-up and treatment of these cases.

**Methods:** We analyzed the ultrasound findings of cervical ectopic pregnancy in 5 cases. The study was performed on a Philips HD 11 XE ultrasound machine using C 5-2 convex and C 8-4 V transvaginal transducers. The size of the gestational sac, trophoblastic reaction and vascularity, presence of an embryo, and its cardiac activity if present were documented.

**Results:** The gestational ages at diagnosis were 6–9 weeks. All 5 cases showed an empty endometrial cavity and a closed internal os; 2 cases showed the presence of only a gestational sac (without a fetal pole) with trophoblastic vascularity; and 3 showed the presence of an embryo within the sac: 2 with cardiac activity and 1 without cardiac activity. All cases underwent curetting. One live ectopic was treated with methotrexate first, and curetting was done later as the patient then complained of bleeding on and off.

**Conclusions:** A cervical ectopic pregnancy is a very rare form of extrauterine pregnancy. Its correct diagnosis helps in timely intervention. Surgical evacuation of the pregnancy alone is not recommended because the cervix is unable to contract, and prolonged bleeding may follow. Hence, expectant management with methotrexate is recommended in nonemergency cases. Ultrasound as an imaging modality helps not only in diagnosis but also in follow-up if it is treated with methotrexate.

### 2374922 Cesarean Scar Endometriosis: Case Series—Ultrasound and Doppler Characteristics

**Kishore Rathod**

*Radiology, Hiranandani Hospital, Thane, Maharashtra, India; Radiology, Apollo Clinic Thane, Maharashtra, India*

**Objectives:** Endometriosis is defined as the presence of ectopic functioning endometrial tissue outside the uterine cavity. Abdominal wall endometrioma presents as a painful swelling resembling surgical lesions. It mostly follows obstetric and gynecologic surgeries like cesarean delivery (commonest), hysterectomy, and tubal ligations. We describe 9 cases of scar endometriosis following cesarean delivery. The varied appearance of the lesion on sonography is discussed. The importance of using a high-frequency linear transducer to diagnose this condition is emphasized.

**Methods:** The study was performed on a Phillips HD 11 XE ultrasound machine using a high-frequency linear 3–12 transducer. The size, location, ultrasound morphology, and color Doppler flow were evaluated.

**Results:** Nine women (age range, 28–38 years) with 11 scar endometriomas (2 women had 2 different nodules at the scar site) were evaluated. Out of 11 nodules, 5 nodules were located between subcutaneous fat and the muscular sheath; in 3 cases, both the subcutaneous and muscular planes were infiltrated; 2 endometriomas were purely subcutaneous; and 1 nodule was entrapped in the muscular layer of the abdominal wall. Out of 11 nodules, 9 were solid hypoechoic with spiculated margins; 1 was predominantly cystic; and 1 was both solid and cystic. Five lesions showed vascularity within; 4 were avascular; and 2 showed minimal peripheral vascularity. Seven out of 9 were subsequently surgically removed and confirmed on histopathology. Two patients responded to a medical line of treatment and refused surgical intervention.

**Conclusions:** A high index of suspicion of scar endometriosis in patients with a relevant clinical history always clinches the diagnosis. Use of a high-frequency linear transducer is strongly recommended to make the diagnosis. Judicious use of B-mode sonography and color Doppler to achieve this diagnosis obviates the need of any further imaging modality like magnetic resonance imaging.

### 2379044 Intrauterine Device Insertion Under Ultrasound Guidance: Clinical Indications

**Adrian Balica,\* Amy Patel, Susan Egan, Charletta Ayers, Gloria Bachmann**

*Obstetrics and Gynecology, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ USA*

**Objectives:** Identification of common clinical indications in our university practice for intrauterine device (IUD) insertion under ultrasound guidance.

**Methods:** All women referred to our gynecologic ultrasound unit for an ultrasound-guided IUD insertion over a 2-year period were evaluated. The IUD insertions were done in the gynecologic ultrasound unit by the same team physician and sonographer.

**Results:** Fifty-five women (ages 20–51 years) were having the IUD inserted for abnormal uterine bleeding (28 patients), contraception (23 patients), and both reasons (4 patients). Of this cohort, referred for ultrasound-guided IUD insertion, 9 patients had a failed attempt in the office, and the remainder (46) were referred, based on the clinical judgment, due to fibroids (17), uterine positioning (10), history of expulsion of the IUD (10), and other (9). Of the 9 patients with failed traditional office attempts, 6 had documentation that the cervix was unable to be sounded or unable to pass more than a few centimeters; 2 were due to extreme retroflexion; and 1 was due to lateral uterine deviation. Of these 9 patients, 7 went on to have successful ultrasound-guided insertion. The success rate of ultrasound-guided insertion was 85%. Of the 8 in whom ultrasound-guided insertion was unsuccessful, 5 experienced intolerable discomfort during the procedure, and 3 had a uterus that was unable to be sounded. Of the patients with a failed IUD attempt in the office, the success rate of ultrasound-guided IUD insertion was 77%.

**Conclusions:** Based on our data, we believe there are certain clinical indications that warrant sending a patient for ultrasound-guided IUD insertion. These include: an extreme anteverted, retroverted, or deviated uterus, a uterus that cannot be sounded, a previously expelled IUD, and a fibroid uterus with a distorted endometrial cavity. Ultrasound-guided insertion should be considered for training programs. Using ultrasound for guidance would increase patient safety by reducing the risk of perforation as well as allow the learner to understand proper technique and confirm correct placement of the device.

### 2379754 An Application of the Learning Curve—Cumulative Summation Test to Evaluate Training for Diagnosis of Müllerian Duct Anomalies With 3-Dimensional Ultrasound

**M. Angela Pascual<sup>1</sup>,\* Betlem Graupera<sup>1</sup>, Juan Luis Alcázar<sup>2</sup>, Ignacio Rodríguez<sup>1</sup>, Lourdes Hereter<sup>1</sup>, Anna Mallafré<sup>1</sup>, Ana Fernandez-Sanguino<sup>1</sup>, Stefano Guerriero<sup>3</sup>**

*<sup>1</sup>Obstetrics, Gynecology, and Reproduction, Institut Universitari Dexeus, Barcelona, Spain; <sup>2</sup>Obstetrics and Gynecology, Clínica Universitaria de Navarra, Pamplona, Spain; <sup>3</sup>Obstetrics and Gynecology, University of Cagliari, Cagliari, Italy*

**Objectives:** To evaluate the learning curve—cumulative summation test (LC-CUSUM) of 3D ultrasound (3DUS) for the diagnosis of müllerian duct anomalies (MDA) and the deviations of the level of trainees' performance at the control-stage CUSUM.

**Methods:** A 1st-year resident (R1) and a 2nd-year resident (R2) in obstetrics and gynecology received a theoretical and practical course, developed at our center, in order to learn how to analyze the 3DUS volumes on an offline workstation and to classify MDAs according to the European Society of Human Reproduction and Embryology—European Society for Gynaecological Endoscopy consensus. Each trainee worked on 155 3DUS volumes of preselected patients. Their results were evaluated using the LC-CUSUM and standard CUSUM. Time for each volume analysis was calculated for the expert examiner and the 2 trainees. Trainees carried out the volume analysis separately and were blinded to each other's results and to the true diagnosis.

**Results:** R1 and R2 reached competence at the 85th and 58th evaluations, respectively, with success rates of 80% (R1) and 81% (R2), and kept the process under control, with error levels of less than 4.5% until the end of the test. Both trainees significantly reduced the average time of evaluation per volume ( $P < .001$ ).

**Conclusions:** The LC-CUSUM provided quantitative indicators of learning evolution of 3DUS for the diagnosis of MDA by residents in obstetrics and gynecology. The training received by the residents was adequate for diagnosis of uterine anomalies using 3DUS.

### 2383094 Diagnosis of Adenomyosis Using Sonographic Criteria: Expert Preoperative Assessment by Transvaginal Ultrasonography Compared to Definitive Histopathology of the Surgical Specimen

**Olivia Lara,\* Alain Szyller**

*Women's Health, University of Texas Austin Dell School of Medicine, Austin, TX USA*

**Objectives:** We evaluated the role of expert-guided transvaginal ultrasonography (TVUS) as a preoperative diagnostic tool for adenomyosis using specific diagnostic criteria.

**Methods:** A retrospective chart review of 308 patients who underwent hysterectomy for benign pathology over a 3-year period at a community teaching hospital was performed. A review of the surgical pathology reports for these patients was conducted. The charts of these patients were then reviewed for preoperative expert-guided TVUS. Comparisons were made between the results of the TVUS and postoperative pathology reports.

**Results:** Of the 308 patients who were included in the study, 129 (41.8%) were found to have adenomyosis. Of these 129 patients with

adenomyosis, 45 (34.8%) had a preoperative TVUS performed by an expert sonographer. Expert-guided TVUS had a 71.43% sensitivity for extensive adenomyosis as diagnosed on pathology using the following sonographic criteria: enlarged uterus, globular shape of the uterine body, asymmetry between anterior and posterior myometrium walls, heterogeneity of the myometrium with anechoic and hyperechoic areas, microcystic diverticular areas in the myometrium, and blurred transitional zone between the endometrium and myometrium. Routine guided TVUS had a 14.29% sensitivity for diagnosis of adenomyosis using no specific criteria for diagnosis.

**Conclusions:** Expert-guided TVUS has increased sensitivity when diagnosing adenomyosis compared to routine TVUS. Expert-guided TVUS sensitivity is increased further in specimens with extensive disease. A grading system might be evaluated to improve the overall diagnosis of adenomyosis by stratifying its degree of likelihood compared to the extent of the disease.

#### 2384089 Does 3-Dimensional Ultrasonographic Evaluation of Women's Ovarian Reserve Adequately Discriminate Between Young Women With Normal and Poor Ovarian Reserve?

*Sara Cholvi,\* Carmela Valldecabres, Carlos Pascual, Francisco Raga, Antonio Cano*

*Obstetrics and Gynecology, Hospital Clínico Universitario de Valencia, Alginet, Valencia, Spain*

**Objectives:** Currently the determination of anti-müllerian hormone (AMH) levels is considered the gold standard to evaluate the ovarian reserve. Our aim is to evaluate if 3D ultrasonography discriminates adequately between young women with normal and poor ovarian reserve.

**Methods:** Prospective, population-based, cross-sectional study conducted at our Department of Obstetrics, Gynecology, and Reproductive Medicine from January 2009 to September 2015. The study was approved by the Institutional Review Board, and all participants gave informed consent for the trial. A total of 926 healthy women (18–29 years) recruited from students at our university decided to participate in this study. The 3D ultrasonographic sono-automatic volume calculation (AVC), antral follicular count (AFC), and AMH level were determined on days 2–5 of the menstrual cycle to evaluate the ovarian reserve.

**Results:** The prevalence of young women with a poor ovarian reserve based on the determination of AMH ( $<1$  ng/mL) was 4.42% ( $n = 41$ ). Moreover, the prevalence of polycystic ovarian syndrome ascertained by a high AMH level ( $>10$  ng/mL) was 13.1% ( $n = 121$ ). Therefore, 82.5% of our students presented average AMH levels ( $n = 764$ ). On the other hand, the prevalence of young women with a poor ovarian reserve by 3D ultrasonography (AFC  $<10$ ) was 4.85 ( $n = 45$ ). The prevalence of women with polycystic ovaries was 14.25% ( $n = 132$ ). Finally, women with an average AFC by 3D ultrasonography was 80.9% ( $n = 749$ ). No statistically significant differences were observed between both techniques.

**Conclusions:** Exploring women's ovarian reserve by 3D ultrasonographic sono-AVC and AFC seems to precisely correlate with the serum AMH levels. Consequently, estimating women's ovarian reserve by this ultrasonographic mode is very reliable. Therefore, it allows the precise recognition of young women with a diminished ovarian reserve.

#### 2384643 Localization of Essure Microinserts: Easy 3-Dimensional Algorithm

*Adrian Balica, Susan Egan, Chi-Son Kim,\* Phani Simhadri*  
*Obstetrics and Gynecology, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ USA*

**Objectives:** 3D ultrasound with the Z technique is used to obtain the midcoronal plane of the uterus. This technique has been used to check the position of microinsert placement. We present a 4-step algorithm to visualize the microinsert's relationship with the endometrial cavity.

**Methods:** We used a GE Voluson E8 ultrasound system with a transvaginal 5–9-MHz probe in the render mode as follows: (1) Acquire a fundal transverse 2D image at the largest transverse dimension of the endometrial cavity at the fundal region. Adjust the direction of the render box to align with the position of the uterus if needed. (2) In plane A, place the reference line at the midlevel of the endometrial cavity (transverse plane). (3) In plane B, use the Z rotation to align the long axis of the endometrial stripe parallel to the reference line (sagittal plane). (4) In the 3D coronal plane, adjust X and Y rotations to optimize visualization of bilateral microinserts in relation to the endometrial cavity.

**Results:** An easy-to-learn algorithm to visualize proximal ends of microinserts and their relationship to the endometrial cavity.

**Conclusions:** Clinical outcomes are dependent on the location of the microinserts. This algorithm provides an easy-to-learn method that provides visualization of a microinsert's position by 3D transvaginal ultrasound.

#### 2385022 Are the Ultrasonographic Criteria for Polycystic Ovaries Still Necessary for Their Diagnosis?

*Carmela Valldecabres,\* Sara Cholvi, Carlos Pascual, Francisco Raga, Antonio Cano*

*Obstetrics and Gynecology, Hospital Clínico Universitario Valencia, Valencia, Spain*

**Objectives:** Demonstrate if the use of ultrasound is almost necessary for the diagnosis of polycystic ovary syndrome (PCOS) or if there are other useful strategies.

**Methods:** Prospective, population-based, cross-sectional study conducted at our Department of Obstetrics, Gynecology, and Reproductive Medicine from January 2009 to September 2015 to evaluate the prevalence of PCOS with the different current classifications: Rotterdam, National Institutes of Health (NIH), and Excess Androgen Society (EAS) criteria. The study was approved by the Institutional Review Board, and all participants gave informed consent for the trial. Additionally, the prevalence of PCOS with 3D sono-automatic volume calculation, antral follicle count ( $>25$ ), or anti-müllerian hormone (AMH) determination ( $>10$  ng/mL) criteria was ascertained.

**Results:** A total of 926 healthy women (18–29 years) recruited from students at our university decided to participate in this study. The prevalence rates of PCOS under Rotterdam, NIH, and AES criteria were 14.7%, 6.1%, and 10.4%, respectively. Moreover, the prevalence rates of PCOS based on the exclusive 3D ultrasound evaluation or AMH determination were 26.2% and 19.6%, respectively.

**Conclusions:** Our study reveals significant differences when using diverse classification criteria. We believe that a future effort is needed to find the most appropriate definition for PCOS. However, excluding the sonographic criteria in such ovaries seems a mistake, given the many clinical implications associated with an ovary with such a large ovarian reserve.

#### 2385205 Diagnosis of Uncommon Congenital Uterine Anomalies by 3-Dimensional Ultrasound

*Beatriz Valero, Ana Lloveras, Betlem Graupera, Ignacio Rodriguez, Lourdes Hereter, M. Angela Pascual*

*Obstetrics, Gynecology, and Reproduction, Institut Universitari Dexeus, Barcelona, Spain*

**Objectives:** To evaluate the efficacy of 3D ultrasound (3DUS) to diagnose uncommon congenital uterine anomalies, comparing with magnetic resonance imaging (MRI) as the gold standard, using the European Society of Human Reproduction and Embryology–European Society for Gynaecological Endoscopy (ESHRE–ESGE) consensus on the classification of congenital anomalies of the female genital tract.

**Methods:** Sixty-three women with 2DUS suspicion of congenital uterine anomalies were evaluated with 3DUS and MRI. These data were retrospectively analyzed in order to confirm the presence and type of uncommon uterine anomalies in accordance with the ESHRE–ESGE con-



sensus. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated with 95% confidence intervals. Agreement between the 2 methods was evaluated using the  $\kappa$  index.

**Results:** Uncommon congenital uterine anomalies were diagnosed by 3DUS in 14 (22.6%) women of the 63 included in the study group: 1 (1.6%) dysmorphic uterus, 6 (9.5%) bicorporeal uteri, and 7 (11.1%) hemiuteri. MRI diagnosed uncommon congenital uterine anomalies in 15 (23.8%) patients. In 1 case where 3DUS diagnosed a septate uterus, MRI diagnosed a bicorporeal uterus. 3DUS demonstrated 85.7% sensitivity, 100% specificity, 100% PPV, 98.2% NPV, and 0.91  $\kappa$  in the diagnosis of bicorporeal uteri. For dysmorphic uteri and hemiuteri, sensitivity, specificity, PPV, and NPV all were 100% with 1.00  $\kappa$ .

**Conclusions:** Ultrasonographic diagnosis with 3DUS is very efficient in the diagnosis of the uncommon congenital uterine anomalies, with a good level of agreement with MRI using the ESHRE–ESGE consensus.

#### 2385465 Intestinal Polyps in Asymptomatic Postmenopausal Women Identified During a Routine Gynecologic Transvaginal Ultrasound Evaluation

*Claudia Maksoud,\* Yara Leitão*

*Ultrasound, Centro de Pesquisa em Medicina Tropical de Rondônia, Rio de Janeiro, Brazil*

**Objectives:** To show 2 cases of intestinal polyps suspected at transvaginal evaluation, confirmed by posterior colonoscopy and biopsy, in asymptomatic postmenopausal women who were scanned for routine gynecologic evaluation.

**Methods:** B-mode and color Doppler images were acquired with a Philips 2–5-MHz HD11 transvaginal probe, and no previous intestinal preparation was required. We scanned the patients in sagittal, transverse, and oblique views. Color Doppler was used to identify the vascular pattern and fluxometry to measure the resistance index.

**Results:** The lesions were hypoechoic, circumscribed, and solid, and the vascular pediculus and its insertion in the mucosal intestinal surface were seen using color Doppler and power Doppler. There was no visible sign of invasion of the intestinal walls that could be certainly defined by ultrasound aspects.

**Conclusions:** When performing gynecologic transvaginal studies, it is important to carefully look at the structures and adjacent organs because it is possible to identify intestinal lesions even in the asymptomatic phase, assisting in early detection and improving the prognosis.

#### 2385918 Two- and Three-Dimensional Transvaginal Ultrasound With Power Doppler in Prediction of Endometrial Malignancy in Patients With Postmenopausal Bleeding

*Karol Dokus,\* Jozef Visnovsky, Zuzana Laucekova, Erik Kudela, Jan Danko*

*Gynecology and Obstetrics, Jessenius Faculty of Medicine, Comenius University, Martin, Slovakia*

**Objectives:** The aim of the study was to correlate 3D power Doppler ultrasound (PD-US) scans of the endometrium with biopsy findings in women with postmenopausal uterine bleeding in order to create a clinical model for evaluation of the risk of endometrial malignancy.

**Methods:** A total of 324 patients underwent transvaginal 2D grayscale and 3D PD-US examination of the endometrium before getting endometrial biopsy. Inclusion criteria were one-off post-menopausal bleeding and an endometrial sagittal thickness  $>5$  mm. The ultrasound image showing the most vascularized section of the endometrium on 3D PD-US was used to estimate endometrial thickness, and the vascularity index (VI) was calculated using virtual organ computer-aided analysis software. A thorough patient history was taken to collect clinical information. Multivariate logistic regression analysis was used to create a model for prediction of endometrial malignancy.

**Results:** There were 22 (6.79%) endometrial carcinomas, 34 (10.49%) endometrial hyperplasias, and 268 (82.71%) benign endometrial findings. Women with an endometrial malignancy were older (median age, 64 vs 54 years;  $P = .026$ ) and had a thicker endometrium (median thickness, 12.8 vs 6.8 mm;  $P = .015$ ) and higher VI values compared to the histologically negative group, but compared with the hyperplasia group, the differences were insignificant (median age, 64 vs 62 years;  $P = .744$ ; median thickness, 12.8 vs 10.7 mm;  $P = .338$ ), and VI values were also comparable.

**Conclusions:** Postmenopausal bleeding is a frequent cause of consultation in gynecologic practice. This is also the main alarming clinical sign of endometrial carcinoma. The transvaginal ultrasound scan has become the “gold standard” in the initial examination. It is a powerful tool to estimate the individual risk of malignancy in symptomatic postmenopausal women in order to optimize management. (This study was supported by grant APVV-14-0815.)

### High-Frequency Clinical and Preclinical Imaging

#### 2382440 Assessing Fasciocutaneous Flaps With High-Frequency Ultrasound and Photoacoustic Imaging

*Maria Stanczak<sup>1</sup>,\* Edita Aksamietiene<sup>2</sup>, John Eisenbrey<sup>1</sup>, Lucas Bryant<sup>2</sup>, Flemming Forsberg<sup>1</sup>, Ji-Bin Liu<sup>1</sup>, Edmund Pribitkin<sup>2</sup>*

*<sup>1</sup>Radiology, <sup>2</sup>Otolaryngology–Head and Neck Surgery, Thomas Jefferson University, Philadelphia, PA USA*

**Objectives:** Fasciocutaneous flaps are transfers of skin and subcutaneous tissues to another location on the body. The intent is to cover large superficial defects in the skin relying on vessels within the fascial planes for vascular supply. Vascular compromise is the most common cause of flap failure, resulting in surgical removal and/or therapeutic intervention. This study investigated changes in flap perfusion and saturated oxygen levels with high-frequency ultrasound (US) and photoacoustic imaging (PA) as early predictors of failure.

**Methods:** Six Sprague Dawley rats (550–650 g) received  $8 \times 2.5$ -mm bilateral anterior abdominal wall fasciocutaneous flaps as part of an ongoing study. The left epigastric artery was injured, resulting in compromised left flaps, preserving right flaps as controls. High-frequency (21–70 MHz) bilateral grayscale US and PA was conducted preoperatively and 24 and 48 hours postoperatively with a Vevo LAZR scanner (Visualsonics, Toronto, Canada). PA was performed with fixed parameters (gain 31 dB, depth 16 mm, 100% PA power). Changes in vascular perfusion and saturated oxygen levels were averaged over 50–60 frames. Measurements were compared bilaterally in all fasciocutaneous flaps.

**Results:** In all rats, flaps were visualized as linear hyperechoic structures with a thickness of 1.7–2.3 mm. Preoperative abdominal wall imaging observed minimal vascular perfusion patterns with average saturated oxygen levels within the right and left sides of 79% and 75%, respectively. Increased vascular patterns developed 24 hours after surgery in the control flaps, with a decrease in vascular perfusion visualized in the compromised flaps. PA of the compromised flaps measured decreased oxygen levels 24 and 48 hours postoperatively (56% and 59%, respectively). Contralaterally, the control flaps yielded postsurgical oxygen levels of 86% and 80% at the same time points. Of the rats followed to completion, half the compromised flaps ended in failure.

**Conclusions:** Assessment of fasciocutaneous flaps in Sprague Dawley rats can be achieved with high-frequency US and PA. Changes in vascular perfusion and saturated oxygen levels can be observed 24 and 48 hours after surgery.

**2383795 The Use of Blood Oxygen Level–Dependent Magnetic Resonance Imaging in Growth-Restricted Fetuses**  
**Carolina Bibbo<sup>1</sup>,\* Jie Luo<sup>2</sup>, Esra Turk<sup>2</sup>, Borjan Gagoski<sup>3</sup>, Mark Vangel<sup>4</sup>, Arvind Palanisamy<sup>5</sup>, Elfar Adalsteinsson<sup>2,6</sup>, Ellen Grant<sup>3</sup>, Julian Robinson<sup>1</sup>**

<sup>1</sup>Obstetrics and Gynecology, Brigham and Women's Hospital, Boston, MA USA; <sup>2</sup>Madrid-MIT M+ Vision Consortium in the Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, MA USA; <sup>3</sup>Fetal-Neonatal Neuroimaging and Developmental Science Center, Boston Children's Hospital, Harvard Medical School, Boston, MA USA; <sup>4</sup>Massachusetts General Hospital, Boston, MA USA; <sup>5</sup>Anesthesia, Brigham and Women's Hospital, Boston, MA USA; <sup>6</sup>Electrical Engineering and Computer Science, Harvard–Massachusetts Institute of Technology Health Sciences and Technology, Cambridge, MA USA

**Objectives:** To use blood oxygen level–dependent magnetic resonance imaging (BOLD-MRI) to investigate changes in placental and fetal tissue oxygenation associated with transient maternal oxygenation in pregnancies where uteroplacental insufficiency is suspected.

**Methods:** Singleton and twin pregnancies were recruited for BOLD-MRI if the ultrasound-estimated fetal weight was below the 10th percentile or if umbilical artery Doppler measurements were abnormal. Controls were also recruited. BOLD-MRI signaling was measured in the fetal brain, liver, thigh, and placenta. The total acquisition time was 30 minutes, and 3 different 10-minute phases of maternal oxygenation were investigated: (1) normoxic, (2) hyperoxic, and (3) normoxic. The oxygen supply was alternated from room air (21% oxygen) to oxygen (15 L/min) via a non-rebreathing facial mask and back to room air.

**Results:** Eight subjects were recruited: 2 singleton and 6 twin pregnancies. There were 6 cases (either abnormal umbilical artery Dopplers in utero or small for gestational age at birth weight) and 8 controls. The gestational age of enrollment ranged from 26–34 weeks. In placental tissue, the rate of signal intensity increase with oxygen and the rate of signal intensity decrease after oxygen were both slower in the cases as opposed to the controls (0.053 vs 0.097 min<sup>-1</sup>;  $P < .01$ ; and  $-0.068$  vs  $-0.15$  min<sup>-1</sup>;  $P < .01$ , respectively). After oxygen exposure, the signal intensity was higher for the cases (12.3% vs 7.1%;  $P < .01$ ). In the brain, liver, and thigh, the signal intensity after oxygen exposure was lower for the cases in comparison with the controls ( $-3.1\%$  vs  $-0.2\%$ ;  $P < .01$ ;  $-3.8\%$  vs  $6.6\%$ ;  $P < .01$ ; and  $-6.1\%$  vs  $2.1\%$ ;  $P < .05$ , respectively).

**Conclusions:** BOLD-MRI can be used to study changes in placental and fetal tissue oxygenation. Although preliminary, we postulate that these findings showing different oxygen dynamics in the insufficient placenta suggest less efficient oxygen transport, and the lower postoxy-genation plateaus in the fetal tissue with insufficient placenta could suggest increased fetal oxygen extraction.

## Interventional-Intraoperative Ultrasound

**2326724 A Technique for Preoperative Axillary Lymph Node Tattooing in Patients With Breast Cancer**

**John Downey<sup>1</sup>,\* Jafi Lipson<sup>1</sup>, Debra Ikeda<sup>1</sup>, Irene Wapnir<sup>2</sup>**  
<sup>1</sup>Breast Imaging, Radiology, <sup>2</sup>Surgery, Stanford University School of Medicine, Stanford, CA USA

**Objectives:** To describe the ultrasound (US) technique for tattooing axillary lymph nodes (ALNs) after lymph node (LN) biopsy in patients with breast cancer.

**Methods:** Tattooing was performed under real-time US guidance using a 5-cm-long, 21-gauge hypodermic needle attached to a 1-mL tuberculin syringe containing 1 mL of carbon suspension tattoo ink (SPOT; GI-Supply, Inc). Imaging was performed with the patient in a supine oblique position with the patient's arm over the head. The anatomically an-

terior and lateral aspects of the node and perinodal fat were marked with ink. The only regions of the LN not targeted for ink tattooing were the hilum and the posterior cortex and perinodal fat. At least 0.5 mL of ink was used.

**Results:** The optimal technique for intraoperative visualization was determined to be tattooing the anatomically anterior and lateral aspects of the LN cortex and the adjacent perinodal fat using at least 0.5 mL of ink. Tattooed LNs that had undergone biopsy and tattooing months prior to surgery were visible intraoperatively and on histologic evaluation. Factors contributing to suboptimal visualization of the tattooed lymph node included using less than 0.5 mL of ink, tattooing only the superficial cortex and not the perinodal fat, and tattooing a portion of the LN that was not visible with the patient in the operative position.

**Conclusions:** The most easily accessed portion of the LN during the US procedure may not be the portion of the LN most easily seen intraoperatively. Locating and tattooing the anatomically anterior and lateral aspects of the LN, regardless of the patient position and orientation of the US probe, is the primary challenge. Doing so will maximize the likelihood that the tattoo ink will be visible by the surgeon when the patient is in a supine position with the arm abducted 90° using an axillary incision. Tattooing using less than 0.5 mL resulted in suboptimal visualization. Using a larger volume of ink may be judged necessary for larger LNs, very fatty axillae, and deeply seated nodes. Tattooing of ALNs under US guidance is a straightforward technique, which can be performed at the time of biopsy and obviates the need for future preoperative wire localization of the LN.

**2380574 Sonographic Guidance for Pancreas Transplant Biopsies: Technique, Complications, and Outcomes**

**Louise Truong,\* Tara Morgan, Liina Poder, Vickie Feldstein**  
 Radiology, University of California San Francisco, Berkeley, CA USA

**Objectives:** Pancreas transplants are increasingly performed and evaluated using ultrasound (US). Transplant biopsy results assess for rejection and/or pancreatitis and inform clinical management. Real-time US is often used to guide these percutaneous procedures. The objective of this study was to review technique, efficacy, and safety of these biopsies.

**Methods:** All pancreas transplant biopsies performed at a single large tertiary transplant center from January 1, 2000, to August 1, 2015 were retrospectively reviewed. The medical records were searched to assess for number of core biopsy samples obtained and histologic results, including adequacy in each case. Clinical evidence of biopsy-related complications within 30 days was also reviewed. Minor complications were defined as arteriovenous fistula, pseudoaneurysm, or hemorrhage that did not need further intervention. Major complications were defined as complications requiring intervention such as transfusion of blood products or an invasive procedure (by surgery or interventional radiology).

**Results:** A total of 131 biopsies were performed in 97 patients. In 98 cases (75%), a single biopsy pass with an 18-gauge, 22-mm-penetration, spring-loaded core biopsy device (Bard Biopsy Systems, Inc) was performed. Technical success was achieved in 123/131 biopsies (94%). Eight biopsies were nondiagnostic (6%), with 2 requiring repeat US-guided biopsy. There were a total of 11 (8%) minor complications and 0 major complications. Minor postbiopsy complications included 6 small arteriovenous fistulae, 4 small peritransplant hematomas, and 1 small pseudoaneurysm with minimal postbiopsy bleeding. These complications were clinically insignificant, and subsequent imaging demonstrated resolution of these minor complications.

**Conclusions:** US-guided percutaneous pancreatic transplant core biopsy can be safely performed with high technical success and with a low rate of complications. The most common complication is a small arteriovenous fistula, typically clinically insignificant and managed expectantly.

**2381037 Role of Sonography in the Treatment of Chronic Granulomatous Mastitis****Shruthi Ram<sup>1</sup>, \* Emily Ritchie<sup>2</sup>, Shadi Aminololama-Shakeri<sup>1</sup>**<sup>1</sup>Radiology, University of California Davis Medical Center, Sacramento, CA USA; <sup>2</sup>Radiology, Sentara RMH Medical Group, Harrisonburg, VA USA

**Objectives:** (1) To discuss the methodology and role of ultrasound-guided aspiration of symptomatic fluid collections as a treatment option in chronic granulomatous mastitis of the breast, presenting our institutional experience with corresponding illustrative images. (2) To review the clinical presentation, radiologic and pathologic features, and diagnostic criteria of granulomatous mastitis. (3) To discuss existing treatment options for the disease and the morbidity associated with wide surgical excision and corticosteroid therapy, based on comprehensive review of the current literature.

**Methods:** In addition to reviewing clinical, radiologic, and pathologic features of granulomatous mastitis, we present our institutional experience including the details of our unique treatment technique and discuss the natural course of the disease and patient outcomes.

**Results:** Thus far, ultrasound is typically only used for the diagnosis and follow-up of granulomatous mastitis of the breast. Standard treatment options include high-dose corticosteroid therapy and surgical excision of affected tissue. We have developed a minimally invasive, ultrasound-guided aspiration method for symptomatic fluid collections in treatment of the disease as an alternative. In the past 2 years, we have treated 5 patients with the diagnosis of chronic granulomatous mastitis in our institution using the aforementioned technique. All patients were able to avoid the adverse effects and morbidity associated with lumpectomy, mastectomy, and long-term corticosteroid use with eventual resolution of the inflammatory process and good cosmetic outcomes.

**Conclusions:** We recommend consideration of the minimally invasive repeat ultrasound-guided aspiration technique for symptomatic fluid collections in patients diagnosed with chronic granulomatous mastitis as an alternative to more invasive surgery or long-term corticosteroid therapy.

**2385500 Sonographic Pictorial Review of Image-Guided Renal Interventions and Their Complications****Vijayanadh Ojili<sup>1</sup>, \* Michael Barker<sup>1</sup>, Arpit Nagar<sup>2</sup>**<sup>1</sup>Radiology, University of Texas Health Science Center, San Antonio, TX USA; <sup>2</sup>Radiology, Ohio State University Wexner Medical Center, Columbus, OH USA

**Objectives:** (1) To highlight the utility of ultrasound in guiding renal interventional procedures. (2) To describe the sonographic findings of complications associated with renal interventional procedures and correlate these with computed tomographic (CT)/angiographic findings where available.

**Methods:** A brief review of ultrasound-guided renal interventions will be presented. The sonographic findings of complications associated with renal interventions (hematomas, pseudoaneurysms, and arteriovenous fistulas) will be described and correlated with CT/angiographic findings where available. Pertinent management issues will be briefly discussed.

**Results:** Not applicable as this is a pictorial review.

**Conclusions:** Ultrasound plays a major role in guiding nonvascular renal interventional procedures. It also plays an important role in diagnosing complications associated with these procedures, of which some are potentially life threatening and require aggressive management.

**2387663 Doppler Imaging of the Periorbital Vessels****Robert Bard***Biofoundation, New York, NY USA*

**Objectives:** Map anatomy of periorbital arteries/veins to avoid puncture during facial procedures. Many cases of blindness are now attributed to vascular trauma.

**Methods:** Thirty-nine patients were mapped by 3D Doppler 17-MHz ultrasound in 6 periorbital regions. Maps were provided pre-treatment to surgical staff.

**Results:** Imaging showed 25% of aberrant facial arteries that were avoided during treatment. No arterial damage was incurred.

**Conclusions:** Presurgical vascular mapping may avoid iatrogenic trauma.

**2387685 Ultrasound Guidance for Hyaluronidase Injections****Robert Bard***Biofoundation, New York, NY USA*

**Objectives:** Hyaluronidase may reduce the volume effect if the aliquot is intact. Sonography will differentiate an intact aliquot from hemorrhage.

**Methods:** Four patients with 84 injection sites were scanned for volume.

**Results:** Twenty-five percent had full or moderate dispersion of the aliquot. Seventy-five percent had no dispersion of the aliquot.

**Conclusions:** Hyaluronidase may be used effectively when no dispersion of the aliquot is noted.

**Musculoskeletal Ultrasound****2342432 Ultrasound-Guided Lateral Femoral Cutaneous Nerve Block for the Diagnosis and Treatment of Meralgia Paresthetica: Case Report****Carmen Wong***Physical Medicine and Rehabilitation, University of Colorado, Denver, CO USA*

**Objectives:** A patient presents with bilateral burning pain and numbness in the lateral aspect of proximal thighs for 18 months with occasional toe curling. Laboratory diagnostic workup was negative for nutritional deficiencies and endocrine pathologies. Nerve conduction studies were also within normal limits. There was concern for an L2 radiculopathy, in addition to meralgia paresthetica. Since the patient's burning pain was interfering with function and quality of life, the patient received bilateral lateral femoral cutaneous nerve (LFCN) injections with lidocaine using ultrasound guidance for diagnosis and treatment of pain.

**Methods:** The anterior superior iliac spine was palpated, and the ultrasound transducer was placed medially below the level of the inguinal ligament. The femoral artery and vein were visualized; the transducer was advanced laterally and caudally until the LFCN was visualized lateral to the sartorius muscle border. After aspiration, 2 mL of 1% lidocaine was injected into the area of the nerve.

**Results:** The patient's pain decreased more than 50% percent on a visual analog scale bilaterally at the initial visit. On 2-week follow-up, the patient reported 90%–95% improvement of pain on the left thigh and 60% improvement on the right lateral thigh. The patient reported a 75% decrease in paresthesias when ambulating. There were no adverse effects, such as weakness, infection, or erythema at the injection site.

**Conclusions:** LFCN blocks have been used for harvesting skin grafts; however, they are rarely used in the diagnosis and treatment of meralgia paresthetica. Ultrasound imaging allows for real-time visualization of anatomy and needle positioning, allowing for successful placement of the injectate into the area of interest. Ultrasound-guided lidocaine injection



of the LFCN for meralgia paresthetica can be both a therapeutic and diagnostic procedure with minimal adverse effects and is a minimally invasive procedure.

#### 2367161 Sonographic Evaluation of Ligaments and Tendons of the Hands

**Jonelle Thomas,\* Cristy Gustas, Dylan Simmons**

*Radiology, Penn State Hershey Medical Center; Hershey, PA USA*

**Objectives:** Fine spatial resolution and dynamic assessment make sonography useful for the evaluation of ligaments and tendons in the hand. The objective of this exhibit is to review the normal sonographic appearance of tendons and ligaments in the hand, to illustrate dynamic imaging techniques for these structures, and to demonstrate common pathology of the tendons and ligaments as seen on sonography.

**Methods:** Normal anatomic sonographic appearances of the flexor and extensor tendons of the fingers and ulnar and radial collateral ligaments will be demonstrated from control patients. The picture archiving and communication system was searched for pathologic cases involving the hand, and clinical notes were reviewed to confirm sonographic diagnosis.

**Results:** Pathologic cases that will be demonstrated include sagittal band rupture, acute pulley tear with bowstringing, flexor and extensor tendon tear, trigger finger, ulnar collateral ligament tear, Stener lesion, giant cell tumor of the tendon sheath, Dupuytren contracture, tenosynovitis, and digital neuroma mimicking tendon injury.

**Conclusions:** Linear high-frequency transducers and a dynamic technique make ultrasound extremely useful for evaluation of the ligaments and tendons of the hands. After reviewing this exhibit, the learner will be comfortable with normal and abnormal sonographic appearances of the hands.

#### 2369681 Diagnostic Accuracy of Ultrasound Among Patients With Osteoarthritis in Detecting Knee Synovitis Using Magnetic Resonance Imaging as the Reference Standard: A Meta-analysis

**Irene Bandong<sup>1,2</sup>,\* Richard Pacardo<sup>3</sup>**

*<sup>1</sup>Institute of Radiology, St. Luke's Medical Center, Quezon City, Philippines; <sup>2</sup>Radiology, Seamen's Hospital, Manila, Philippines;*

*<sup>3</sup>Radiology, Ospital ng Maynila, Manila, Philippines*

**Objectives:** To determine the accuracy of ultrasound in the detection of knee synovitis among patients with osteoarthritis using magnetic resonance imaging as the reference standard.

**Methods:** An extensive search of PubMed, Embase, and the Cochrane Central Registry was performed by 2 reviewers (I.B. and R.P.). This was completed by hand search of references from relevant articles and review papers published from 1995 to 2014. A modified Quality Assessment of Diagnostic Accuracy Studies checklist was used to assess the quality of the included studies. The 2 reviewers independently selected eligible studies, with disagreement resolved by consensus. The same 2 reviewers independently extracted data from the full text of the selected 2 studies. Data analysis was used to generate the measures of diagnostic accuracy and summary receiver operating characteristic curves.

**Results:** Diagnostic performance of ultrasound in detecting joint effusion, pooled from 2 studies, demonstrated sensitivity of 86.2% and specificity of 73.1%. Sonographic feature of synovial thickening showed sensitivity of 98.6% and specificity of 77.1%. Popliteal cysts had sensitivity of 85.5% and specificity of 100%.

**Conclusions:** Sonographic findings of joint effusion and the presence of popliteal cysts have moderate sensitivity and high specificity. The sonographic feature of synovial thickening has moderate sensitivity and specificity. Thus, these findings may be used as diagnostic criteria in evaluating patients with knee osteoarthritis.

#### 2371631 Utilizing Sonographic Imaging to Compare 2 Clinical Methods of Lower Trapezius Assessment

**Dexter Witt,\* Nancy Talbott**

*Rehabilitation Sciences, University of Cincinnati, Cincinnati, OH USA*

**Objectives:** The clinical assessment of strength in the lower trapezius (LT) is traditionally performed in a prone position with the arm overhead. For individuals with shoulder pathologies, this position may be difficult to achieve. Sitting with the arm in neutral is often more comfortable, and most patients with shoulder pain are able to adduct and depress the scapula in this position without increasing pain. Ultrasound (US) imaging is a reliable method of determining LT thickness and can be used to assess LT activation. The purpose of this study was to utilize US imaging to compare LT thickness during a traditional prone manual muscle test (MMT) with thickness during sitting scapular adduction and depression (SADD).

**Methods:** Eighteen subjects consented to participate. With the subject sitting, the US transducer was used to clearly visualize the LT. An image of the LT was captured at rest and when the subject pulled the scapula down and back. This process was repeated 3 times bilaterally. Next, the subject was moved to a traditional prone MMT position in which US images were taken at rest and under 3 states of resistance. Images were stored and thickness measurements of the LT taken using ImageJ. Descriptive analyses were used to summarize mean LT thickness. An analysis of variance was used to analyze the association between LT thickness, position, and condition.

**Results:** In sitting, LT thickness significantly increased from 3.2 mm at rest to 7.7 mm during active SADD. In prone, LT thickness significantly increased from 3.3 mm at rest to 5.6 mm during an active hold, 6.0 mm during a hold with a 2-lb weight, and 6.2 mm during a hold against maximal resistance. While rest values during sitting and prone testing were not significantly different, the thickness of the LT was significantly greater during the active scapular movement in sitting than during the prone maximal MMT.

**Conclusions:** This study suggests that active SADD in sitting can produce LT thickening greater than the traditional prone MMT position. For patients with movement restrictions or significant pain with overhead movements, the sitting scapular activity may be more appropriate for examination than the traditional MMT position.

#### 2375191 In Vivo Measurements Using Ultrasound Imaging to Investigate Intersession Reliability of 3 Grades of Posterior Glenohumeral Mobilization Used by Practitioners of Manual Therapy

**Dexter Witt,\* Nancy Talbott**

*Rehabilitation Sciences, University of Cincinnati, Cincinnati, OH USA*

**Objectives:** Grades of posterior humeral mobilizations (PHM) are commonly used in manual therapy procedures performed by physical therapists, chiropractors, and osteopaths. These procedures are used to promote positive outcomes in patients with shoulder dysfunction. Evidence is limited to support the ability to reliably reproduce graded mobilization movements between sessions. The purpose of this study was to use ultrasound imaging to assess the amount of posterior humeral movement during grades of PMH on 2 separate days and to determine the intersession reliability during 3 grades of mobilization.

**Methods:** Eleven healthy subjects were tested. In supine, the shoulder was positioned in 55° of abduction and 30° of horizontal adduction. An ultrasound transducer was placed over the anterior glenohumeral joint and the position of the humerus recorded at rest and as a single examiner applied grade 1, grade 2, and grade 3 PHM. Each grade was repeated 3 times on both arms. Measurements were repeated 1 week later. Posterior movement of the humeral head during the mobilization was de-

terminated by measuring the position of the humeral head in reference to the coracoid process.

**Results:** Grade 1 mean movement was 2.3 mm during session 1, which was significantly different from the 2.9 mm of movement measured during session 2. Grade 2 mean movement was 8.1 mm during session 1 and 8.6 mm during session 2, while grade 3 mean movement was 11.3 mm during session 1 and 11.5 mm during session 2. Grade 2 and grade 3 differences between sessions were not significant. Interrater intraclass correlation coefficients were 0.810 for grade 1, 0.647 for grade 2, and 0.549 for grade 3.

**Conclusions:** Differences between sessions were small for each grade of PHM, and reliability was lower at higher grades. Results emphasize the variability between sessions of a single examiner who is attempting to mobilize the same subject in a similar manner on 2 different days. Further study is needed to determine if this variability can be decreased within a single examiner.

### 2375204 A Sonographic Investigation Into the Manual Assessment of Inferior Glenohumeral Joint Stiffness

*Dexter Witt,\* Nancy Talbott*

*Rehabilitation Sciences, University of Cincinnati, Cincinnati, OH USA*

**Objectives:** Manual assessment of joint stiffness is often incorporated into the examination of the shoulder and can assist clinicians in identifying the need for increasing flexibility or emphasizing stabilization. Testing, however, can be performed in multiple positions, including (1) a neutral position (NP) in which the arm is at the side; (2) an open packed position (OP) in which the arm is in 55° of abduction and 30° of horizontal adduction; and (3) an abducted position (AP) in which the arm is in 90° of abduction. The purpose of this study was to determine via ultrasound (US) imaging the intratester reliability of manual assessment of inferior glenohumeral stiffness in each of the 3 positions and to determine if the positions significantly altered stiffness values.

**Methods:** Fourteen healthy adults participated. In sitting, the arm was placed in the NP with the US transducer over the superior glenohumeral joint. US images were taken at rest and as a maximal inferior translational force was applied through a handheld dynamometer. This process was repeated 3 times in the NP and in the AP. The subject was then placed in a supine position and testing was performed 3 times in the OP. The humeral head position was measured in reference to the superior acromion and the amount of movement determined by the distance the humeral head moved from the rest position. Stiffness was calculated as force per millimeter (N/mm).

**Results:** Intrasession intraclass correlations coefficient values were good for the NP (0.841) and for the AP (0.739) and poor for the OP (0.392). Mean stiffness values were highest in the AP (149.1 N/mm) and significantly lower in the in the OP (86.7 N/mm). Mean stiffness in the NP was 113.9 N/mm, which was not significantly different from the other positions.

**Conclusions:** High correlations suggest that testing for stiffness is clinically reliable in either the NP or the AP. Lower correlation values in the OP do not support the ability to repeatedly assess stiffness in the position. Because of the differences in the stiffness values in the 3 positions, results of this study also suggest that clinical assessments for stiffness should be repeated in a single test position.

### 2375215 Sonographic Assessment of the Lower Trapezius During Dynamic Overhead Movement

*Dexter Witt,\* Nancy Talbott*

*Rehabilitation Sciences, University of Cincinnati, Cincinnati, OH USA*

**Objectives:** Static assessment of the lower trapezius (LT) has been found to be reliable using ultrasound imaging (USI) and offers the

ability to compare LT thickness in individuals with and without suspected LT involvement when the arm is placed and held in one position. LT activity, however, is required to appropriately function during dynamic movements of the arm, suggesting that dynamic assessment of the LT is needed. The purpose of this study was to use USI to measure and describe thickness changes in the LT during dynamic overhead arm movement.

**Methods:** Thirty-five adults consented to participate. With the subject sitting, the US transducer was placed lateral to T7 and adjusted to clearly visualize the LT and the ipsilateral trapezius. A video of the LT was recorded as the subject performed the following flexion movements: 0–120, 0–90, and 0–180. Each test was repeated 3 times on the dominant arm. During the 0–120 movement, measurements of LT thickness were taken when the arm was at 0° and at 120°; during the 0–90 movement, measurements were taken at 0° and at 90°; and during the 0–180 movement, measurements were taken at end range. Intraclass correlation coefficients (ICCs) were calculated to determine the reliability of LT measurements between repetitions. Descriptive analyses and an analysis of variance were used to determine the association between thickness and joint position.

**Results:** The ICC for LT measurement was 0.964. Mean LT thickness at rest was 3.25 mm. Mean thickness significantly increased from rest to 4.1 mm at 90° and from rest to 3.8 mm at 120°. Mean thickness at end range was 6.1 mm. The thickness at 90° was not significantly different from the thickness at 120°, but the thickness at end range was significantly greater than the thickness at 90° and 120°.

**Conclusions:** LT muscle thickness as measured by USI increased from rest to midrange and from midrange to end range. Resting thickness of the LT nearly doubled as the arm reached end range. USI can be used to reliably measure LT thickness during dynamic movement, offering clinicians an objective methodology for LT assessment.

### 2375234 In Vivo Sonographic Assessment of Thickness Changes in the Serratus Anterior During Overhead Humeral Movement

*Dexter Witt,\* Nancy Talbott*

*Rehabilitation Sciences, University of Cincinnati, Cincinnati, OH USA*

**Objectives:** Activation of the serratus anterior (SA) is essential to normal shoulder mechanics, with alterations in SA contraction associated with shoulder pathologies. Although past research has used electromyography to assess SA activity, ultrasound imaging (USI) offers a method to visualize the SA and to measure SA thickness changes during isometric testing. Considering the dynamic function of the SA, expanding USI methodology to include dynamic assessment may improve recognition of abnormal SA activation during arm motion. The purpose of this study was to measure and describe thickness changes in the SA during dynamic overhead arm movement.

**Methods:** Thirty-five adults consented to participate. With the subject sitting, the US transducer was placed on the ribcage at the level of T7 and the SA visualized. A video of the SA was recorded as the subject performed the following flexion movements: 0–120, 0–90, and 0–180. Each test was repeated 3 times on the dominant arm. During the 0–120 movement, measurements of SA thickness were taken at 0° and at 120°; during the 0–90 movement, measurements were taken at 0° and at 90°; and during the 0–180 movement, measurements were taken at end range. Intraclass correlation coefficients (ICCs) were calculated to determine the reliability of SA measurements between repetitions. Descriptive analyses and an analysis of variance were used to determine the association between thickness and joint position.

**Results:** The ICC for SA measurement was 0.917. Mean SA thickness at rest was 5.1 mm. Mean thickness significantly increased from rest to 8.5 mm at 90° and from rest to 8.9 mm at 120°. Mean thickness at end range was 10.4 mm. The thickness at 90° was not significantly different from the thickness at 120°, but the thickness at end range was significantly greater than the thickness at 90° and at 120°.

**Conclusions:** SA muscle thickness as measured by USI increased as the arm was elevated, showing close to a 100% increase in thickness from rest to end range. While there may be greater SA thickening at end range than at midrange, a significant difference can be achieved at lower ranges for those individuals whose pain or stiffness limits overhead movement.

#### 2377192 Can Physical Therapy Students Reliably Measure Humeral Head Position on Ultrasound Images?

**Dexter Witt**

*Rehabilitation Sciences, University of Cincinnati, Cincinnati, OH USA*

**Objectives:** Physical therapy curricula have expanded to increase emphasis on the importance of imaging. Ultrasound imaging (UI) is one such imaging technique that is being used with greater frequency in musculoskeletal differential diagnosis and intervention. One challenge with UI, however, is the consistency of measurements of images by novices. Once an acceptable image has been acquired, the image must be interpreted similarly between individuals to have equivalent input into a decision-making process. Instruction and the use of selected images may improve this consistency to facilitate the goal of the profession to improve the knowledge of physical therapy graduates in the area of UI. The purpose of this study was to examine the reliability of measurements of humeral head position made by 2 physical therapy students after exposure and instruction in UI.

**Methods:** Twelve healthy subjects consented to participate. Ultrasound images were taken on each subject during 3 grades of posterior mobilization. One therapist performed the mobilization; 1 therapist performed UI; 1 student recorded forces during the mobilizations; and 1 student stored captured images. Both arms were mobilized 3 times on day 1. Testing was repeated 1 week later. In addition, a second therapist completed 3 repetitions of the mobilizations on the nondominant arm. Following the completion of testing, students were instructed in the use of ImageJ to measure humeral head position. Instruction consisted of a 30-minute demonstration of the measurements by an individual who was registered in musculoskeletal ultrasound. Each student independently completed 288 measurements. Intraclass correlation coefficients (ICCs) were calculated to determine the reliability of the measurements.

**Results:** The ICC between measurers was 0.966. Measurements were not significantly different between measurers.

**Conclusions:** The results of this study suggest that ultrasound images of humeral head position can be reliably measured by physical therapy students after a brief period of instruction. As UI becomes more prevalent in education, research, and the clinic, reliability may not need to be an obstacle for its use.

#### 2378339 In Vivo Measurements of Lower Trapezius Muscle Thickness: Interexaminer and Intraexaminer Reliability During Sitting Scapular Adduction and Depression

**Dexter Witt,\* Nancy Talbott**

*Rehabilitation Sciences, University of Cincinnati, Cincinnati, OH USA*

**Objectives:** Manual muscle testing of the lower trapezius (LT) muscle is traditionally performed in prone position with the arm overhead. Many patients with shoulder pathology cannot tolerate this position due to pain or restriction. Most can achieve a sitting position and tolerate an active scapular adduction and depression movement, commonly referred to as a scapular squeeze (SS). Ultrasound imaging can be used to measure any changes in LT thickness that occur during the scapular squeeze and thereby provide an alternate assessment of LT muscle activity. The purpose of this study was to determine the intraexaminer and interexaminer reliability of LT thickness assessments during a sitting SS.

**Methods:** Eighteen healthy adults consented to participate. With the subject sitting, examiner 1 placed the ultrasound transducer lateral to T7 and adjusted the image to visualize the LT muscle and the ipsilateral transverse process. An image was recorded at rest. The subject was then instructed to perform an SS as examiner 2 provided tactile cues. The image was recorded by examiner 1. This process was repeated 3 times on both arms. After rest, examiner 2 recorded the images, and examiner 1 provided the cues. Thickness measurements from captured images were made using ImageJ. Descriptive statistics and intraclass correlation coefficients (ICCs) were calculated for intraexaminer and interexaminer reliability.

**Results:** For examiner 1, mean LT thickness measurements at rest and during an SS were 3.2 and 7.7 mm, respectively. These were not significantly different from the mean thickness values for examiner 2 (3.4 mm at rest and 7.7 mm during the SS). The intraexaminer ICCs for examiner 1 and examiner 2 were 0.970 and 0.950, respectively. The interexaminer ICC was 0.886.

**Conclusions:** This study supports the utility of ultrasound imaging to reliably measure LT thickness during an SS. Measurements made by one examiner had good agreement with measurements made by a second examiner. Sitting may be an acceptable position to measure changes in LT thickness for clinicians seeking to assess LT activity or to promote LT contraction.

#### 2378345 A Sonographic Investigation of Intertester Differences During 3 Grades of Posterior Glenohumeral Mobilization: An In Vivo Comparison of Movement and Force

**Dexter Witt,\* Nancy Talbott, Rebecca Rebitski**

*Rehabilitation Sciences, University of Cincinnati, Cincinnati, OH USA*

**Objectives:** Posterior glenohumeral (GH) mobilizations can be utilized to promote positive outcomes in patients with shoulder dysfunction. Limited in vivo evidence is available that supports the ability of different clinicians to repeatedly utilize similar mobilization movements. In fact, current evidence indicates that despite the wide use of mobilization as a treatment, significant variations between the amount of force and movement between clinicians may exist. The purpose of this study was to use ultrasound imaging to analyze movement and force differences between 2 therapists during the performance of 3 grades of posterior GH mobilization.

**Methods:** Twelve healthy subjects participated. With the subject in the commonly preferred mobilization position, an ultrasound transducer was placed over the anterior GH joint and the position of the humerus recorded at rest and as a single examiner applied 3 grades of posterior mobilizations through a handheld dynamometer. Each grade was repeated 3 times. This process was repeated by a second examiner. Posterior movement of the humeral head was determined by measuring the position of the humeral head in reference to the coracoid process.

**Results:** Grade 1 mean movement was 3.4 mm for therapist 1, which was not significantly different from the 3.0 mm recorded by therapist 2. Grade 2 mean movement was 9.0 mm for therapist 1, which was significantly different from the 5.8 mm produced by therapist 2. Grade 3 mean movement was 12.0 mm for therapist 1, which was also significantly different from the 7.5 mm produced by therapist 2. Force measurements for grade 1 mobilizations were not different between therapists, but forces used during grade 2 and 3 mobilizations were significantly greater for therapist one (22.2 and 42.6 lb, respectively) than for therapist 2 (10.7 and 14.4 lb, respectively).

**Conclusions:** The results of this study suggest that 2 therapists can consistently produce similar grade 1 mobilizations using similar forces, which result in similar joint movement. However, at higher grades, the amount of force and the amount of the resulting movement diverge significantly.



### 2380232 Verification of Isolated Lumbar Deep Muscle Contraction by Magnetic Nerve Root Stimulation Using Ultrasonography

**Shi-Uk Lee**

*Physical Medicine and Rehabilitation, Seoul National University Boramae Medical Center, Seoul, Korea; Rehabilitation Medicine, Seoul National University College of Medicine, Seoul, Korea*

**Objectives:** To evaluate the changes of lumbar deep muscle thickness and cross-sectional area using ultrasonography with magnetic stimulation.

**Methods:** Twelve healthy volunteers ( $39.6 \pm 10.0$  years) without low back pain during 3 months were included. Magnetic stimulation was done on the L5 and S1 roots with a figure-8 coil. To confirm the proper motor root stimulation, the surface electrode was put on the tibialis anterior (L5) and abductor hallucis (S1) muscles, and the hot spots of magnetic stimulation were found with 50% of maximal magnetic stimulation and determined the stimulation threshold lowering the magnetic intensity by 5%. Ultrasonography was used to assess the changes of L5 and S1 lumbar multifidus (superficial and deep) cross-sectional area and thickness with maximal magnetic stimulation. The cross-sectional area (CSA) and thickness were evaluated with image acquisition program ImageJ software (National Institutes of Health, Bethesda, MD). The Wilcoxon signed rank was used to compare outcomes between before and after stimulations.

**Results:** The mean minimal threshold was  $29.6\% \pm 3.8\%$  of maximal stimulation intensity. With minimal magnetic stimulation, thicknesses of the L5 and S1 deep multifidus (DM) were increased from  $1.25 \pm 0.20$  and  $1.42 \pm 0.23$  cm to  $1.40 \pm 0.27$  and  $1.56 \pm 0.34$  cm, respectively ( $P = .005$ ;  $P = .003$ ). CSAs of L5 and S1 DM were also increased from  $2.26 \pm 0.18$  and  $1.40 \pm 0.26$  cm<sup>2</sup> to  $2.37 \pm 0.18$  and  $1.56 \pm 0.34$  cm<sup>2</sup>, respectively ( $P = .002$ ;  $P = .002$ ). However, thicknesses of the L5 and S1 superficial multifidus (SM) were not changed from  $1.92 \pm 0.21$  and  $2.04 \pm 0.20$  cm to  $1.91 \pm 0.33$  and  $1.96 \pm 0.33$  cm ( $P = .211$ ;  $P = .199$ ) and CSAs of L5 and S1 were also not changed from  $4.29 \pm 0.53$  and  $5.48 \pm 0.32$  cm<sup>2</sup> to  $4.42 \pm 0.42$  and  $5.64 \pm 0.38$  cm<sup>2</sup>. With maximal magnetic stimulation, thicknesses of the L5 and S1 DM and SM were increased (L5 DM,  $1.29 \pm 0.26$  and  $1.46 \pm 0.27$  cm;  $P = .028$ ; L5 SM,  $2.01 \pm 0.42$  and  $2.24 \pm 0.39$  cm;  $P = .005$ ; S1 DM,  $1.29 \pm 0.19$  and  $1.67 \pm 0.29$  cm;  $P = .002$ ; S1 SM,  $1.90 \pm 0.36$  and  $2.30 \pm 0.36$  cm;  $P = .002$ ). CSAs of L5 and S1 DM and SM were also increased (all  $P$  values were  $.002$ ).

**Conclusions:** Deep lumbar muscles could be stimulated with lumbar motor root magnetic stimulation. With minimal stimulation, the thickness and CSA of the lumbosacral DM measured using ultrasonography were increased.

### 2383189 The Detection of the Intra-articular Loose Bodies in the Joints by Point-of-Care Ultrasonography

**Dae Jeong<sup>1,2</sup>, \*E. Nambi Ramamoorthy<sup>2</sup>, James Daniels<sup>2</sup>**

*<sup>1</sup>Geriatrics, Thomas Jefferson University Hospital, Philadelphia, PA USA; <sup>2</sup>Sports Medicine, Southern Illinois University, Quincy, IL USA*

**Objectives:** To discuss the value of point-of care ultrasonography (US) in the assessment of loose bodies compared to other imaging modalities.

**Methods:** We selected 3 cases with a final diagnosis of loose bodies proven by US from a sports medicine clinic. All 3 cases were examined by primary care sports medicine fellows under supervision of the sports medicine program director with extensive experience in musculoskeletal US: case 1, 29-year-old male with a history of patella dislocation with frequent locking, catching, and severe pain on left knee for 1 year with a negative magnetic resonance imaging (MRI) study; case 2, 58-year-old male with a 2-year history of limited range of motion of the left elbow and pain on the lateral side of the elbow joint since an injury from a fall onto an outstretched hand with a negative elbow x-ray; case 3,

47-year-old male with acute right 1st metatarsophalangeal joint pain with swelling and erythema with a remote history of turf toe.

**Results:** In all 3 cases, we were able to visualize loose bodies easily by a standard musculoskeletal US protocol for the affected joint, which were missed by other imaging modalities and/or the orthopedic specialist.

**Conclusions:** US is a valuable tool to detect intra-articular loose bodies, which can be easily missed by history, physical exam, plain x-ray, computed tomography, or MRI/MR angiography. High suspicion, a careful scanning technique, and knowledge of the radiographic studies are essential to make a reliable and correct diagnosis of loose bodies by US.

### 2383206 Comfort of Orthopedic Trainees With Ultrasound-Guided Hip Arthrocentesis Before and After Educational Intervention

**Bradley Ching, \*R. Starr Knight, Nathan Teismann**

*Emergency Medicine, University of California, San Francisco, CA USA*

**Objectives:** Hip arthrocentesis for both the evaluation of joint effusions and injection of analgesia can be a difficult task without the aid of adjunct guidance techniques. Fluoroscopy is a popular modality, though it carries a number of disadvantages, including infrequent availability, decreased portability, and also radiation to both patient and provider. Ultrasound has been shown to be a reliable and accurate guidance tool for hip arthrocentesis without many of the disadvantages of fluoroscopy. Though they are tasked with the care of patients with hip pathology, many orthopedic trainees are not comfortable with ultrasound-guided hip arthrocentesis (USGHA), which can at times delay definitive patient care and management. We sought to evaluate the baseline comfort of orthopedic trainees both before and after a brief educational presentation and cadaver-based workshop on USGHA.

**Methods:** Orthopedic trainees ranging from medical students to chief residents underwent a 15-minute didactic lecture and subsequent hands-on cadaver-based workshop. Participants were surveyed before and after intervention for their experience, comfort, and likelihood of performing USGHA on a 1–10 analog scale.

**Results:** Nineteen participants completed the preintervention survey, and 20 participants completed the postintervention survey. Six of 19 (31.5%) had previous experience with hip arthrocentesis utilizing either fluoroscopy or landmark-based guidance techniques. No participant had previous experience with USGHA. Prior to the intervention, on a 10-point analog scale, the average comfort with USGHA was 1.26, and the average likelihood of performing a USGHA was 2.42. After the intervention, the comfort level had increased to an average of 5.68 and likelihood of performing the procedure in the future to 8.74. Eighteen of 20 (90%) felt as though they were able to identify all relevant anatomic landmarks and obtain the necessary views to perform a USGHA.

**Conclusions:** Our study shows that the confidence and familiarity of novice operators can be greatly increased with a brief educational intervention. Further studies need to be done to investigate the actual accuracy of these trained novice operators.

### 2383507 Development of a New Index of “Muscular Age” Evaluated by Ultrasonography: Quantitative Assessment of the Quadriceps Femoris Muscle and Comparison With Knee Extension Force

**Tsuneo Watanabe<sup>1,4</sup>, \*Hiroki Murakami<sup>2</sup>, Daisuke Fukuoka<sup>5</sup>, Nobuo Terabayashi<sup>3</sup>, Sohee Shin<sup>1</sup>, Tamotsu Yabumoto<sup>1</sup>, Hiroyasu Ito<sup>4</sup>, Hiroshi Fujita<sup>2</sup>, Toshio Matsuoka<sup>4</sup>, Mitsuru Seishima<sup>4</sup>**

*<sup>1</sup>Sports Medicine and Sports Science, <sup>2</sup>Intelligent Image Information, <sup>3</sup>Orthopedic Surgery, Gifu University Graduate School of Medicine, Gifu, Japan; <sup>4</sup>Division of Clinical Laboratory, Gifu University Hospital, Gifu, Japan; <sup>5</sup>Faculty of Education, Gifu University, Gifu, Japan*

**Objectives:** Metabolic syndrome has received increased attention as leading cause of arteriosclerosis in the past few years, and the primary indicator of arteriosclerosis such as “pulsed wave velocity” is widely used as an index of “vascular age” in clinical daily practice. In contrast, although early detection of musculoskeletal disorders is important, no index is available to quantify muscular age at present. The aim of this study was to evaluate the relationship among aging, muscle strength, and the image features analysis of the quadriceps femoris muscle and to develop a “muscular age” index.

**Methods:** One-hundred forty-five healthy volunteers were included in this study. The subjects were classified into 6 groups on the basis of sex and age as follows: under 44 years old (younger group;  $n = 68$ ), 45–64 years old (middle-aged group;  $n = 31$ ), and over 65 years old (elderly group;  $n = 46$ ). We studied a total of 290 lower limbs of 145 participants who underwent both knee extension strength and ultrasound examinations. For the assessment of the muscle quality, the texture analysis was mathematically defined as the following parameters: MEAN, skewness (SKEW), kurtosis (KURT), inverse different moment (IDM), sum of entropy (SUE), and angular second moment (ASM). The knee extension force and the QM thickness (QMT) were also measured.

**Results:** QMT, SKEW, KURT, IDM, ASM, and muscle strength significantly decreased in the elderly group compared with the younger and middle groups. In contrast, MEAN and SUE significantly decreased in the younger group compared with the middle and elderly groups. The developed equation for the estimation of “muscular age” was the following formula: male,  $5.453 \times (-0.413 \times \text{ASM} + 0.439 \times \text{SUE} - 0.387 \times \text{IDM} + 0.397 \times \text{MEAN} - 0.385 \times \text{SKEW} - 0.360 \times \text{KURT} - 0.089 \times \text{QMT} - 0.201 \times \text{height}) + 39.491 + [0.841 \times (\text{age} - 39.491)]$ ; female,  $6.705 \times (-0.400 \times \text{ASM} + 0.406 \times \text{SUE} - 0.384 \times \text{IDM} + 0.375 \times \text{MEAN} - 0.371 \times \text{SKEW} - 0.351 \times \text{KURT} - 0.272 \times \text{QMT} - 0.221 \times \text{height}) + 50.190 + [0.697 \times (\text{age} - 50.190)]$ .

**Conclusions:** The proposed index of muscular age can quantitatively assess muscular morphologic changes due to aging and could be a valuable tool for early detection of musculoskeletal disorders.

#### 2383808 Non-Weight-Bearing and Weight-Bearing Ultrasonography of Select Foot Muscles in Young Asymptomatic Participants: A Descriptive and Reliability Study

Patrick Battaglia<sup>1</sup>, \* Ross Mattox<sup>1</sup>, Brett Winchester<sup>2</sup>, Norman Kettner<sup>1</sup>

<sup>1</sup>Radiology, Logan University, Chesterfield, MO USA; <sup>2</sup>Logan University, Chesterfield, MO USA

**Objectives:** Determine the reliability of ultrasonography when imaging select foot muscles in non-weight-bearing and weight-bearing postures and describe the change in muscle size when weight bearing.

**Methods:** Participants were recruited after Institutional Review Board approval. Two examiners collected long- and short-axis ultrasound images of the abductor hallucis (AH), flexor digitorum brevis (FDB), and quadratus plantae (QP) muscles in the non-weight-bearing and weight-bearing postures. A GE LOGIQ E9 (GE Healthcare, Wauwatosa, WI) ultrasound system was used for image acquisition. Weight-bearing images were collected with the participant standing on a custom-built platform, permitting transducer access to the plantar foot while maintaining hind and fore foot contact.

**Results:** There were 26 participants (17 female) with a mean age of  $25.5 \pm 3.8$  years and a mean body mass index of  $28.0 \pm 7.8$  kg/m<sup>2</sup>. Interexaminer reliability was excellent when measuring the muscles in the short axis (intraclass correlation coefficient [ICC] >0.75) and fair to good in the long-axis (ICC >0.4). Intraexaminer reliability was excellent in both planes for each rater when measuring the AH and FDB. Rater 1 demonstrated excellent reliability in measuring the QP in the short axis and fair-to-good reliability when measuring the QP in the long axis. Rater 2 demonstrated fair-to-good reliability when measuring the QP in both

planes. Weight bearing did not reduce reliability. The AH cross-sectional area (CSA) increased from  $2.47 \pm 0.93$  cm<sup>2</sup> when non-weight bearing to  $2.60 \pm 0.91$  cm<sup>2</sup> when weight bearing. The FDB CSA increased from  $2.03 \pm 0.44$  cm<sup>2</sup> when non-weight bearing to  $2.20 \pm 0.51$  cm<sup>2</sup> when weight bearing. The QP CSA increased from  $1.85 \pm 0.47$  cm<sup>2</sup> when non-weight bearing to  $1.97 \pm 0.50$  cm<sup>2</sup> when weight bearing. All muscles demonstrated a significant increase in CSA when weight bearing.

**Conclusions:** The ability to reliably image these muscles with weight-bearing ultrasonography may permit a greater understanding of the pathophysiology in foot deformities and pain syndromes.

#### 2387029 Sonography of a Morel-Lavallée Lesion of the Knee in a Child

Anjum Bandarkar, \* Adebunmi Adeyiga

Radiology, Children's National Health System, Herndon, VA USA

**Objectives:** Illustrate sonographic findings of a Morel-Lavallée lesion in a 7-year-old boy.

**Methods:** A 7-year-old boy presented with suprapatellar fullness in the left knee and mild localized tenderness. High-frequency sonography was performed to show the focal abnormality. Correlation with knee magnetic resonance imaging helps confirm the sonographic diagnosis.

**Results:** Characteristic sonographic findings are noted and depicted.

**Conclusions:** Focused sonography using a high-frequency transducer can well demonstrate a Morel-Lavallée lesion in the knee.

### Obstetric Ultrasound: Fetal Anomalies

#### 2350818 Antepartum Diagnosis of Skeletal Dysplasia Associated With a Novel Gene Mutation

Robert O'Sullivan, \* Gary Kleinman

Obstetrics and Gynecology, Bridgeport Hospital, Shelton, CT USA

**Objectives:** This is a case report concerning a patient in her first pregnancy whose fetus was noted on a sonogram to have multiple skeletal anomalies. Subsequent genetic testing identified a previously undescribed mutation in the *COL1A1* gene. This case serves to highlight the sonographic features of the skeletal survey encountered in conjunction with the genetic mutation.

**Methods:** The case is reviewed, including pertinent prenatal records, results of genetic testing, and prior sonographic findings. Using PubMed and Google Scholar, a review of the pertinent literature was performed.

**Results:** A 31-year-old female in her first pregnancy with a hitherto uncomplicated course underwent a scheduled anatomic survey at 21 weeks' gestation. The sonogram identified multiple skeletal anomalies, including bowing and shortening of the distal extremities, S-shaped ribs, and a normal facial profile. Following counseling, the patient subsequently elected to undergo dilatation and evacuation. Karyotype and microarray did not identify any genetic anomaly. Targeting sequencing of specific genes associated with skeletal dysplasia showed a heterozygous base pair change in the fetus on the *COL1A1* gene on chromosome 17q21.31-q22 with consequent nucleotide change C.319G. A causing amino acid change P.G1064D. Parental testing demonstrated that this is a de novo mutation. The mutation has not been described previously. *COL1A1* codes for type 1 collagen, and previously described mutations have been associated with osteogenesis imperfecta type 1 and Ehlers-Danlos type 7. As neither parent carried the mutation, recurrence in subsequent pregnancies was determined to be unlikely. A subsequent pregnancy resulted in the live birth of an unaffected child.

**Conclusions:** We present the skeletal anomalies associated with a novel mutation of the *COL1A1* gene.

**2351310 Prenatal Diagnosis of Congenital Dacrocystocele**

**Robert O'Sullivan, Saki Onda, Gary Kleinman, Steven Laifer**  
*Obstetrics and Gynecology, Bridgeport Hospital, Shelton, CT USA*

**Objectives:** This is a case report concerning a patient in her fourth pregnancy whose fetus was noted on a sonogram to have a cystic structure medial to the right eye, approximately 8 mm in size. The location and appearance were in keeping with dacrocystocele. This report serves to highlight the sonographic features in addition to the pathophysiology of dacrocystocele.

**Methods:** The case is reviewed, including pertinent prenatal records, results of genetic testing, and prior sonographic findings. Using PubMed and Google Scholar, a review of the relevant literature was performed.

**Results:** A 43-year-old patient in her fourth pregnancy attended for a fetal sonogram at 32 weeks to measure fetal growth. Prior sonograms including an anatomic survey and nuchal translucency measurement were within normal limits. Medial to the right orbit and lateral to the nose was an 8-mm circumscribed structure. The patient attended for follow-up imaging, and on subsequent scans, no change in size was observed. The patient subsequently underwent vaginal delivery of a live female infant. The facial profile appeared within normal limits, and subsequent pediatric and ophthalmologic review following delivery determined that no action in the neonatal period was necessary. Congenital dacrocystoceles are rarely encountered in clinical practice, with an estimated incidence of 1 in 3800. The majority are detected clinically following delivery; less commonly they are seen on prenatal sonograms. Subsequent treatment is usually indicated due to the risk of dacrocystitis and mucocoele formation in the nasal passage with subsequent airway obstruction.

**Conclusions:** Congenital dacrocystocele is rarely encountered on prenatal imaging. We recommend sequential imaging to ensure expansion is not present and close follow-up after delivery due to the potential complications of dacrocystitis and airway obstruction.

**2371388 Prenatal Microarray Analysis in Pregnancies Complicated by Advanced Maternal Age or Fetal Sonographic Anomalies in the Setting of a Normal Karyotype**

**Anna Palatnik<sup>1</sup>, \*Sheetal Patel<sup>2</sup>, Jeffrey Dungan<sup>1</sup>, Andrea Rock<sup>2</sup>, Nina Gotteiner<sup>2</sup>**

<sup>1</sup>Obstetrics and Gynecology, Northwestern University, Feinberg School of Medicine, Chicago, IL USA; <sup>2</sup>Pediatrics, Northwestern University, Chicago, IL USA

**Objectives:** To assess the added value of microarray analysis to the conventional karyotype testing among pregnancies complicated by advanced maternal age (AMA) or abnormal sonographic findings.

**Methods:** This was a case series of 33 pregnancies complicated by either abnormal sonographic findings (n = 22) or AMA (n = 11). All included cases underwent genetic testing and had a normal karyotype but an abnormal microarray. All pregnancies that continued past 20 weeks underwent a detailed sonographic survey and fetal echocardiogram. Pregnancy outcome was recorded when available for all cases included in the analysis.

**Results:** Among fetuses with abnormal sonographic findings, congenital heart defect (CHD) was the most common finding, 10/22 (45%), followed by central nervous system (CNS) anomalies, 8/22 (36%). Fifteen fetuses underwent echocardiograms that were abnormal in 10 cases. The most common CHDs were outflow tract abnormalities, followed by atrioventricular valve atresia. The 22q11.21 deletion was found in 3/10 (30%) of the fetuses with CHD. An additional 7/10 (70%) of the fetuses with CHD had microarray alterations in chromosomes 3, 4, 6, and 15. The most common CNS abnormalities were agenesis of the corpus callosum and ventriculomegaly. Microarray alterations in these cases involved chromosomes 1, 2, 3, 4, 6, 9, and 14. Two patients were lost to fol-

low-up after the genetic testing. One pregnancy was complicated by intrauterine fetal death. Pregnancy termination occurred in 16/31 (51.6%): 11 among pregnancies with abnormal sonographic findings and 5 among women with AMA, prior to performance of a detailed anatomic survey. Only 3 women had an unaffected live-born.

**Conclusions:** Microarray analysis identified clinically significant genomic alterations in pregnancies complicated by AMA or abnormal sonographic findings. The most common fetal abnormality identified in the setting of an abnormal microarray was CHD, with aberrations in the 22q11 region accounting only for 30% of genetic alterations in fetuses with CHD. The microarray affected pregnancy outcomes even in the absence of sonographic abnormalities and enabled early reproductive decision making among women with AMA.

**2373997 Can You Give Me a Hand? Diagnosing and Understanding the Clinical Significance of Fetal Hand Anomalies in Obstetric Ultrasound**

**Thomas Gibson, Kathryn Snyder, Ryan Meek, Roya Sohaey, Karen Oh\***

*Oregon Health and Science University, Portland, OR USA*

**Objectives:** (1) Recognize the most common hand anomalies identified in utero. (2) Understand the spectrum of malformations associated with hand anomalies.

**Methods:** We present a case series of fetal hand anomalies with emphasis on potential associations, prenatal workup, and postnatal follow-up.

**Results:** Fetal anatomy screening utilizes ultrasound to assess for in utero anomalies. While the fetal brain, heart, and body are most often the focus of the exam, prenatal assessment of the extremities is also recommended by a recent executive summary jointly published by the Eunice Kennedy Shriver National Institute of Child Health and Human Development in conjunction with a group of national multidisciplinary societies. The extremities can be difficult to visualize during the ultrasound due to fetal movement and position or maternal scanning characteristics. However, when detected, fetal extremity anomalies can provide critical clues to underlying fetal aneuploidies, syndromes, and dysmorphic conditions. Cases discussed include polydactyly, syndactyly, ectrodactyly, trisomy 18, VACTERL, amniotic band syndrome, trisomy 21, and arthrogryposis. Other associated abnormalities and syndromes that can be seen with hand anomalies are reviewed.

**Conclusions:** Identifying and characterizing fetal hand anomalies can be challenging but important to attempt at the time of the routine anatomy scan. When found prenatally, careful evaluation for associated anatomic abnormalities or dysmorphic conditions should be performed, as a significant portion of fetuses with hand anomalies will have additional malformations.

Table 1. Fetal Hand Anomaly Associations

	Associated Syndrome
Polydactyly	Isolated, familial, trisomy 13 and 18, Meckel-Gruber, diabetic embryopathy
Clinodactyly	Trisomy 21
Clenched hand	Trisomy 18, fetal akinesia deformation sequence
Syndactyly	Familial, amniotic band syndrome, triploidy, Apert syndrome, Poland syndrome
Arthrogryposis	Trisomy 18, distal arthrogryposis, amyoplasia, multiple pterygium syndrome
Radial ray	VACTERL, trisomy 18, Holt-Oram, thrombocytopenia-absent radius, Fanconi anemia
Ectrodactyly	ectrodactyly-ectodermal dysplasia



**2379256 Prenatal Diagnosis of Urinoma and a Dilated Azygous Vein**

**James Maher,\* Randall Kelly, Kathryn Hutton, Mamie Gao**  
*Obstetrics and Gynecology, Texas Tech University Health Sciences Center, Odessa, TX USA*

**Objectives:** We present a case of urinoma and a dilated azygous vein and postnatal follow-up.

**Methods:** A primigravid patient was followed with serial ultrasound from 11 until 33 weeks. The urinoma was followed, and the subsequent changes in the venous drainage and cardiac findings were documented.

**Results:** The patient had a normal 11-week scan. An anatomy scan at 22 weeks demonstrated a right-sided cystic mass of 3.7 cm in diameter, which deflected the right kidney medially. The umbilical vein drained normally into the portal system, and flow in the ductus venosus was normal. The fetal heart including the 3-vessel view was normal. Over the next month, the cyst grew to >7 cm, and the abdominal circumference was >97% for gestational age. The liver was displaced into the left abdomen by the cyst, and the azygos system was noted to dilate. The patient had a spontaneous vaginal delivery at 34 weeks, and postnatal evaluation at the time of surgery confirmed a urinoma from a ruptured renal pelvis.

**Conclusions:** Prenatal diagnosis of a dilated azygos vein is often a marker for disruption of the normal embryologic formation of the abdominal visceral venous drainage associated with heterotaxy. Compensatory dilation of the azygos vein will develop when there is an interruption of the inferior vena cava (IVC) as a result of the right subcardinal vein failing to anastomose with the hepatic sinusoids to form the hepatic segment of the IVC. This is a frequent finding with left atrial isomerism. In our case, the abdominal venous drainage and cardiac findings were normal in the early second trimester. A retroperitoneal cystic mass developed as a result of a urinoma formation, and the progressively enlarging mass gradually displaced the right-sided abdominal viscera including the liver to the left of the midline. By 26 weeks' gestation, the mass had compressed the IVC drainage of the lower body, resulting in a dilation of the azygos vein behind the 4 chambers and a dilated azygos arch emptying into the superior vena cava. Following spontaneous delivery at 34 weeks, the infant had a laparoscopic nephrectomy and removal of the retroperitoneal cyst. With decompression of the abdominal cyst, the normal drainage on the IVC and normal echocardiographic findings were documented. We present an interesting case, which highlights how compression of the IVC by a retroperitoneal mass led to a compensatory dilation of the azygos system.

**2380386 Prenatal Ultrasound Findings of a Large Spontaneous Subdural Hematoma**

**Daphne Landau<sup>1</sup>,\* Assem Abdel-Latif<sup>2</sup>, Mark Souweidane<sup>2</sup>, Natan Haratz<sup>1</sup>**

*<sup>1</sup>Obstetrics and Gynecology, New York Methodist Hospital, Brooklyn, NY USA; <sup>2</sup>Pediatric Neurosurgery, Weill–Cornell Medical College, New York, NY USA*

**Objectives:** This is the 10th reported case in the medical literature of a prenatally diagnosed spontaneous intrauterine subdural hemorrhage, as well as the largest volume and the first treated by surgical evacuation without neurologic sequelae to date.

**Methods:** Ultrasonography (US) performed at 31 weeks for a patient measuring size greater than dates on exam revealed bilateral hydrocephalus and a midline shift by a hypoechoic extra-axial intracranial mass suspicious for a spontaneous subdural hematoma. Targeted US of the fetus revealed no other structural abnormalities. Subsequent fetal magnetic resonance imaging (MRI) confirmed these findings.

**Results:** A c-section was performed at 35 weeks. The newborn was managed on day 1 of life with transfontanelar aspiration and bilateral craniotomy for hematoma evacuation. She maintained steady improvement and was discharged with home services 21 days postoperatively.

**Conclusions:** US is likely to be the initial imaging modality on

which subdural hematoma is diagnosed. Only a handful of specialized academic centers will have a fetal MRI machine as well as properly trained neuroradiologists, underscoring the importance of the skilled sonologist as the front line for prenatal pathologic diagnosis. This is the first reported case of surgical evacuation with no postnatal neurologic sequelae identified and the earliest diagnosed case resulting in a live birth. We believe our earlier diagnosis at 31 weeks contributed to the successful outcome in our patient and underscores the need for sonologists to familiarize themselves with both normal and abnormal neurosonography in order to continue to make this early prenatal diagnosis possible.

Table 1. Previously Reported Cases

Authors	Gestational Age, wk	Hematoma Volume/Side	Intervention	Outcome
Mac Donald (1977)	38	53 cc/bilateral convexity	Subdural tap	Hypotonia at 6 mo
Gunn (1985)	42	3 pts, 1 had 10 cc blood	Subdural tap in 1	Neonatal death (day 3 of life), 1 hypotonic Neonatal death (day 14 of life)
Mateos (1987)	35	220 cc/R with intra-ventricular and intra-parenchymal blood	Surgical	
Demir (1989)	33	NA	NA	Intrauterine fetal demise
Nougeria (1992)	37	NA/R convexity	Burr hole evacuation	Developmental delay
Kawabata (1993)	35	100 g/R convexity	NA	Intrauterine fetal demise
Sohda (1996)	37	NA/posterior convexity	Subdural tap	Developmentally normal at 13 mo
Akman and Cracco (2000)	32	150 cc/R convexity	Burr hole evacuation	Seizures and speech delay
Pitalis (2002)	22	NA	NA	Termination of pregnancy

**2384001 Evolution in Womb: Sonographic Pictorial Review of Common and Uncommon Congenital Fetal Anomalies**

**Vijayanadh Ojili<sup>1</sup>,\* Neeraj Kaur<sup>1</sup>, Arpit Nagar<sup>2</sup>**

*<sup>1</sup>Radiology, University of Texas Health Science Center, San Antonio, TX USA; <sup>2</sup>Radiology, Ohio State University Wexner Medical Center, Columbus, OH USA*

**Objectives:** To describe the antenatal sonographic findings of a wide spectrum of congenital fetal anomalies and correlate these with magnetic resonance imaging (MRI) findings where available.

**Methods:** A brief review of congenital fetal anomalies (Arnold-Chiari malformation, Dandy-Walker malformation, holoprosencephaly, congenital diaphragmatic hernia, duodenal atresia, bladder outlet obstruction, etc) will be presented. The sonographic findings will be described and correlated with MRI findings if available. Pertinent management issues will be briefly discussed.

**Results:** Not applicable as this is a pictorial review.

**Conclusions:** The clinical outcome of various congenital fetal

anomalies may range from being totally asymptomatic to potentially life-threatening conditions, which may result in fetal demise. Therefore, it is important for radiologists and obstetricians to accurately diagnose these conditions in a timely fashion, which greatly impact the prognosis. Sonography is the initial antenatal imaging test performed and will provide diagnosis in most cases.

### 2384730 A Case of Prenatal Diagnosis of Split-Hand/Foot Malformation and Long-Bone Deficiency

**Nickolas Teigen,\* Barrie Suskin, Pe'er Dar**

*Obstetrics and Gynecology, Montefiore Medical Center/Albert Einstein College of Medicine, Bronx, NY USA*

**Objectives:** Split-hand/foot malformation with long-bone deficiency (SHFLD) is a rare condition seen in 1:8500–20,000 newborns. It is characterized by the association of ectrodactyly, syndactyly, and malformations of the long bones, especially tibial defects, including tibial hemimelia, hypoplasia, aplasia, or dysplasia. The condition is inherited in an autosomal dominant manner with reduced penetrance and variable expressivity. Susceptibility loci have been identified, with most cases associated with microduplication at the 17p13.3 locus.

**Methods:** The patient, a 26-year-old G4P1 African American female, was referred at 23 weeks 3 days from an outside institution for evaluation of abnormal fetal upper and lower extremities seen on anatomy ultrasound. The patient's past medical history was significant for asthma, obesity, sickle cell trait, depression, and sciatica. The patient's past obstetric history was significant for 1 full-term spontaneous vaginal birth of a normal female, 1 elective early termination of pregnancy, and 1 spontaneous abortion. The partner's past medical history was noncontributory.

**Results:** On detailed ultrasound evaluation, the upper extremities are notable for V-shaped bilateral ectrodactyly with bony syndactyly of the lateral fingers. The right lower extremity was notable for a bowed femur, absent fibula, short tibia, and abnormal foot with few bones. The left lower extremity displayed a normal femur, absent fibula, short tibia, and abnormal foot with few bones and only 1 demonstrable toe. No other anomalies were noted. Following extensive counseling, the patient declined any invasive genetic testing as well as pregnancy termination. The patient had normal fetal echocardiography, and fetal growth remained adequate throughout the pregnancy. Microarray comparative genomic hybridization will be sent on the newborn after delivery.

**Conclusions:** SHFLD with long-bone deficiency is a devastating skeletal anomaly that can be easily detected on a second-trimester anatomic scan. It is likely that detection of the anomaly would have been possible by an early anatomic scan and early genetic testing and would allow the patient a more reasonable time for decision making.

### 2385008 Prenatal Diagnosis of Sacrococcygeal Fetus in Fetu: A Case Highlighting the Utility of Serial Ultrasound

**Jeffrey Denney<sup>1</sup>,\* Christy Stanley<sup>1</sup>, Lou Ann Armstrong<sup>1</sup>, Jayne Marshall<sup>1</sup>, Bethany Settle<sup>1</sup>, Chad Haldeman-Englert<sup>2,3</sup>**

<sup>1</sup>*Obstetrics and Gynecology, Section on Maternal-Fetal Medicine,*

<sup>2</sup>*Pediatrics, Section on Medical Genetics, Wake Forest University School of Medicine, Winston-Salem, NC USA;*

<sup>3</sup>*Fullerton Genetics Center, Asheville, NC USA*

**Objectives:** Fetus in fetu (FIF) is a rare congenital anomaly defined as an internal or external mass with fetiform structures demonstrating an axial skeleton and significant organogenesis. Prenatal diagnosis of FIF has been mostly limited to the intra-abdominal region. However, there are limited case reports of FIF in other anatomic locations. We present a sacrococcygeal FIF diagnosed on routine prenatal ultrasound that was clearly differentiable from a sacrococcygeal teratoma (SCT).

**Methods:** An anatomic survey was performed at 18 weeks' gestation. Fetal magnetic resonance imaging (MRI) was performed to better delineate the lesion. To supplement fetal growth monitoring in context

of the growing mass, additional ultrasounds were performed weekly to evaluate size, continually characterize the mass, monitor middle cerebral artery Doppler, and screen for prehydropic signs.

**Results:** Fetal ultrasound at 18 weeks' gestation demonstrated a sacrococcygeal mass measuring  $4.7 \times 3.3 \times 4.4$  cm. The mass was heterogeneous in appearance and was noted to have a singular feeding vessel by color angiography. Fetal MRI findings were consistent with a sacrococcygeal teratoma. With the increasing size of the mass, subsequent ultrasounds allowed for visualization of fetal bone within the mass, including vertebral bodies, 2 femurs, tibia/fibula pairs, and feet. These findings were strongly suggestive of FIF, and the patient was counseled accordingly. The fetus was delivered by repeat cesarean section at 37 weeks due to growth restriction. On day of life 2, the  $15 \times 7 \times 12$ -cm mass was excised. Pathologic evaluation confirmed the presence of a vertebral axis and axial skeleton, verifying the suspected diagnosis of FIF. Organogenesis within the mass included lung, pancreas, adrenal, and intestinal structures (gastric, small intestine, and large intestinal mucosa). No immature teratomatous elements or malignancy were identified.

**Conclusions:** We present a sacrococcygeal FIF with a prenatal workup that earmarks serial ultrasound as the primary tool used for differentiating FIF from the more commonplace SCT. Differentiation from SCT is key for both counseling and discussion of prognosis, given that 11%–35% of SCTs are malignant.

### 2385912 Fetal Magnetic Resonance Imaging: A Look Into Its Utility in the Prenatal Diagnosis of Congenital Anomalies

**Danielle Tate, Hemanth Veluswamy,\* Lindsay Meyers,**

**Akosua Sintim-Damoa, Jeffery Copeland**

*University of Tennessee, Memphis, TN USA*

**Objectives:** We sought to investigate the utility of fetal magnetic resonance imaging (MRI) in the diagnosis of fetal anomalies suspected on prenatal ultrasound.

**Methods:** We performed a retrospective review of 165 patients who underwent fetal MRI studies secondary to suspected fetal anomalies first detected via ultrasound. Fetal MRI reports were categorized as either confirming the suspected ultrasound diagnosis, reporting a new finding not previously seen on ultrasound, or definitively diagnosing a questionable anomaly seen on prior ultrasound. Neonatal assessments performed in the immediate postnatal period were then obtained in 111 patients. Neonatal assessments were categorized as those that confirmed the suspected fetal MRI diagnosis, reported a new finding not seen on fetal MRI, or reported findings inconsistent with fetal MRI.

**Results:** Of the cases reviewed, fetal MRI confirmed the suspected diagnosis in 65% of the cases. Fetal MRI was able to identify a previously undiagnosed fetal anomaly in 24% of the cases. In cases where ultrasound reported a questionable diagnosis, fetal MRI was able to give a definitive diagnosis in 15% of the cases. Of all suspected fetal anomalies that underwent fetal MRI, central nervous system anomalies accounted for the majority (53%). In the neonatal period, neonatal assessment confirmed diagnosis in 89% of cases, revealed a new finding in 10% of cases, and found inconsistent findings in 17% of cases of the patients that underwent fetal MRI. Of those neonates who underwent assessment, fetal MRI more accurately identified congenital anomalies in the antenatal period when compared to prenatal ultrasound: 78% vs 70% ( $P = .03$ ).

**Conclusions:** Fetal MRI may serve as a useful tool to confidently identify suspected fetal anomalies. In combination with ultrasound, fetal MRI will allow for improved antenatal and neonatal care.

**2387197 Do Antenatal Ultrasonographic Measurements of Omphalocele Size Determine the Mode of Delivery?****Clark Johnson<sup>1</sup>, \* Rachel Mazza<sup>1</sup>, Janice Henderson<sup>1</sup>, Robert Ehsanipoor<sup>2</sup>**<sup>1</sup>Gynecology and Obstetrics, Johns Hopkins School of Medicine, Baltimore, MD USA; <sup>2</sup>Gynecology and Obstetrics, Sinai Hospital, Baltimore, MD USA

**Objectives:** To determine the relationship of the dimensions of an omphalocele, when present, to the decision to permit and proceed with a trial of labor at time of delivery.

**Methods:** We performed a retrospective cohort study of all pregnancies with a diagnosis of omphalocele that delivered at our university center between 2002 and 2015. We examined the relationship between antenatal omphalocele dimensions (including diameter and relationship to other fetal measurements) and compared these measurements to whether or not the patient attempted a trial of labor. Patients were not included if there was decision to not resuscitate the neonate at delivery due to multiple anomalies.

**Results:** A total of 33 patients were included in analysis. Of these, 9 underwent cesarean delivery for obstetric indications besides the presence of the omphalocele. Of the 24 patients remaining, 17 were permitted a trial of labor (including 1 trial of labor after cesarean), and of those, 10 ended with a vaginal delivery. Notably, 7 cases delivered specifically for the indication of the fetal omphalocele. There was no significant association between a variety of omphalocele measurements and ratios with whether or not a trial of labor was attempted. The largest omphalocele to labor was 85 mm in diameter and resulted in a vaginal delivery and was without sequelae.

**Conclusions:** The decision to permit a trial of labor with a known fetal omphalocele depends on a number of factors, including largely expert opinion on the safety depending on omphalocele size. We demonstrate that individual decisions regarding attempting a trial of labor may not be consistently determined by omphalocele size.

Table 1. Comparison Between Those Attempting Labor and Those Undergoing Cesarean Delivery for Omphalocele

	Attempted Trial of Labor (n = 17)	Cesarean Delivery for Omphalocele Indication (n = 7)	P
Gestational age at delivery, wk	36.66 (34.72–38.61)	38.13 (35.48–40.77)	.37
Gestational age at last ultrasound prior to delivery, wk	31.53 (29.13–33.93)	33.66 (29.13–38.19)	.32
Omphalocele diameter, mm	47.70 (36.88–58.53)	60.14 (34.11–86.18)	.24
Omphalocele diameter/abdominal circumference	0.19 (0.15–0.22)	0.16 (0.03–0.30)	.61
Omphalocele diameter/femur length	0.83 (0.67–1.00)	0.72 (0.28–1.16)	.50
Omphalocele diameter/head circumference	0.16 (0.13–0.20)	0.15 (0.05–0.24)	.61

Data are presented as mean (95% confidence interval).

**Obstetric Ultrasound: Fetal Growth****2380773 Do Decreases in Estimate Fetal Weight Percentile on Ultrasound Between the Second and Third Trimesters Impact Neonatal Outcomes in Normally Grown Fetuses?****Jennifer Amorosa,\* Felipe Tudela, Luciana Vieira, Kelly Zafman, Eric Bergh, Katherine Connolly, Kathy Matthews, Meredith Miller, Angela Bianco**

Obstetrics and Gynecology, Icahn School of Medicine, Mt Sinai Medical Center, New York, NY USA

**Objectives:** Fetal growth restriction plays a major role in perinatal morbidity and mortality. Less is known about those fetuses whose estimated fetal weight percentile (EFW%) decreases over time while still remaining at a “normal” weight (EFW >10%, <90%). The purpose of this study was to see if a decrease in EFW of 20% between the 2nd and 3rd trimesters in a “normal”-weight fetus contributes to adverse neonatal outcomes.

**Methods:** We performed a retrospective cohort study of singleton pregnancies who had growth ultrasound during the 2nd (18–22 weeks) and 3rd (30–34 weeks) trimesters between June 2011 and March 2015. Fetuses with growth restriction (EFW <10%), macrosomia (EFW >90%) or anomalies were excluded. Demographics, delivery data, and composite neonatal outcomes (sepsis, respiratory distress, intubation, intraventricular hemorrhage, necrotizing enterocolitis, pneumonia, neonatal death, and 5-minute Apgars <5) were collected. Fetuses with an EFW% change of ≥20% between the 2 scans were compared to those fetuses that did not. Multivariable log-binomial regression models were used to estimate prevalence ratios and corresponding 95% confidence intervals. We controlled for age, parity, and body mass index (BMI).

**Results:** Of 5063 patients, 1866 (36.8%) showed a ≥20% decrease in EFW% between the 2nd and 3rd trimesters. This group had a statistically significant ( $P < .05$ ) risk of birth weight <2500 g (10.66% vs 3.19%;  $P < .0001$ ) and preterm delivery <37 weeks (8.74% vs 6.01%;  $P = .0003$ ). There was no significant difference in adverse neonatal outcome (4.34% vs 3.53%;  $P = .1497$ ). This remained true when the results were adjusted for maternal age, BMI, and parity.

**Conclusions:** Prospective parents are often concerned if their fetus has what they perceive as a significant drop in EFW% between the 2nd and 3rd trimesters. Prior studies have addressed percentile changes between the 1st and 2nd trimesters and between 2 scans performed in the 3rd trimester. This is the first study to directly compare EFW% change between the 2nd and 3rd trimesters. While infants who exhibited decreases in EFW% between the 2nd and 3rd trimesters were at a slightly higher risk of preterm birth and low birth weight, there was no significant increased risk of adverse composite neonatal outcomes.

**2384833 Fetal Penile Measurements in a Racially Mixed Population****Roger Newman<sup>1</sup>, \* Lori Cruze<sup>4</sup>, Elizabeth Una<sup>5</sup>, James Kiger<sup>2</sup>, Jeffery Korte<sup>3</sup>**<sup>1</sup>Obstetrics and Gynecology, <sup>2</sup>Pediatrics, <sup>3</sup>Public Health Sciences, Medical University of South Carolina, Charleston, SC USA;<sup>4</sup>Biology, Wofford College, Spartanburg, SC USA; <sup>5</sup>Obstetrics and Gynecology, Southern Illinois University School of Medicine, Springfield, IL USA

**Objectives:** Perform fetal and newborn penile measurements and identify variables that affect penile size.

**Methods:** Women (n = 119; 59 white/60 black) with a singleton male fetus were recruited between 18–22 weeks' gestation. Exclusion criteria were uncertain gestational age (GA), fetal anomalies, progesterone use, or any endocrine disorder. AIUM-certified sonographers performed fetal penile measurements. Freeze-frame images and electronic calipers were used to measure fetal penile length (FPL) from the scrotal junction to the tip of the glans. Penile width (FPW) was measured at the midshaft.



Measurements were repeated 3 times and mean values calculated. Fetal penile volume [fPV: (fPW/2)<sup>2</sup> × fPL] was calculated. Neonatal genital measures were obtained prior to discharge using the same methods by research staff.

**Results:** fPL, fPW, and fPV all increased significantly between 18–22 weeks' gestation and were highly correlated with neonatal measures. fPL was significantly predicted by GA, maternal race, and gravity (all  $P < .001$ ) and were 41% of the variance. GA ( $P < .001$ ) was a significant predictor of fPW, and GA and gravity were predictors of fPV. Maternal race ( $P < .003$ ) was the only significant predictor of neonatal PL and PV.

**Conclusions:** Racial differences have been reported in newborn and infant penile size, but this is the first report of fetal racial differences. During gestation, androgen hormonal concentrations vary by race and gravity, and these affect fetal penile size. New reference standards are needed to better diagnose micropenis or ambiguous genitalia in a racially diverse population.

Table 1. Penile Measurements by GA (Mean ± SE)

GA, wk	PL, mm	PW, mm	PV, mm <sup>3</sup>
Fetal			
18	5.0 ± 0.6	4.2 ± 0.3	23.9 ± 6.0
19	6.2 ± 0.2	4.8 ± 0.2	36.9 ± 3.6
20	6.6 ± 0.2	5.2 ± 0.8	46.3 ± 2.0
21	7.3 ± 0.2	5.2 ± 0.8	55.7 ± 3.5
22	9.2 ± 0.5	5.9 ± 0.2	81.3 ± 6.7
Neonatal			
37	25.3 ± 1.4	10.4 ± 0.4	680 ± 53.5
38	27.1 ± 1.5	10.3 ± 0.3	739 ± 62.2
39	25.4 ± 0.9	10.6 ± 0.2	700 ± 39.9
40	27.0 ± 0.9	10.6 ± 0.2	775 ± 41.5
41	26.2 ± 1.9	10.0 ± 0.5	661 ± 65.5

## Obstetric Ultrasound: General

### 2348862 Middle Cerebral Artery Doppler Ultrasound May Not Be Predictive of Fetal Anemia in Fetuses With Alpha Thalassemia

Shareece Davis-Nelson<sup>1</sup>, \* Yvonne Gollin

Obstetrics and Gynecology, Loma Linda University Medical Center, Loma Linda, CA USA

**Objectives:** To determine a threshold for the middle cerebral artery (MCA) peak systolic velocity (PSV) multiples of the median (MoM) that should prompt intrauterine transfusion (IUT) in fetal alpha thalassemia.

**Methods:** When hydrops was diagnosed, IUT was performed, and the MCA PSV MoM was calculated immediately before and after each procedure using previously described techniques. Additionally, hemocue assessment, a complete blood count, and hemoglobin electrophoreses were performed.

**Results:** A couple of Southeast Asian descent that had a prior neonatal death from nonimmune hydrops presented for care. The mother was found to have *cis* (—/αα) deletions for alpha thalassemia on sequencing. At the time of the anatomy ultrasound, fetal hydrops was noted. Subsequently, paternal alpha thalassemia molecular analysis also demonstrated *cis* deletions, and fetal analysis confirmed 4-gene deletion alpha thalassemia. At 19 weeks 6 days, hydrops was noted. The MCA PSV was 1.3 MoM. The case was discussed at a multidisciplinary conference between Radiology, Maternal-Fetal Medicine, Ethics, Pediatric Cardiology, Genetics, and Neonatology. The measurements were repeated, and Transplant Medicine counseled the couple. They opted for intervention for 4-

gene deletion alpha thalassemia (which traditionally causes “hydrops fetalis”); based on the multidisciplinary conference proceedings, we performed the initial IUT at 20 weeks 4 days of gestation. The preprocedure MCA PSV MoM values were between 0.93–1.38. At the last IUT, there was an isolated MCA PSV MoM of 1.65; it is unclear if there was fetal movement that caused this occurrence.

**Conclusions:** Consideration should be given toward a modification of the MCA PSV MoM threshold for intrauterine transfusion in the setting of fetal 4-gene deletion alpha thalassemia.

Table 1. Preprocedure and Postprocedure MCA PSV MoM

Transfusion # (wk Gestation)	Preprocedure MCA PSV MoM	Postprocedure MCA PSV MoM	Initial Hemoglobin
1 (20 4/7)	1.38	1.13	6.3
2 (21)	0.93	0.85	—
3 (23 6/7)	1.03	1.02	9.2
4 (27 3/7)	1.37	0.97	9.7
5 (30 3/7)	1.3	0.8	10.5
6 (35)	1.65	1.02	10.2

### 2351609 Polyhydramnios and Adverse Perinatal Outcomes: Comparing 2 Ultrasound Methods of Diagnosing Polyhydramnios and Their Association With Adverse Perinatal Outcomes

Tehila Avitan<sup>1</sup>, \* Jennifer Hutcheon<sup>1,2</sup>, Chantal Mayer<sup>1,2</sup>

<sup>1</sup>Maternal-Fetal Medicine, BC Women's Hospital, Vancouver, British Columbia, Canada; <sup>2</sup>Provincial Health Services Authority, Vancouver, British Columbia, Canada

**Objectives:** The aim of this study was to determine which measure of polyhydramnios, amniotic fluid index (AFI) or deepest vertical pocket (DVP) is more strongly correlated with adverse perinatal outcomes.

**Methods:** This retrospective cohort study was drawn from singleton pregnancies receiving a prenatal ultrasound scan >28+0 weeks' gestation at the BC Women's Hospital from 2000–2014. Polyhydramnios was defined as an AFI ≥24 cm or DVP >8 cm. Ultrasound data were linked with the hospital's quality-controlled obstetric and neonatal database, which contains abstracted medical chart data. An adverse perinatal outcome was defined as any of: stillbirth, in-hospital newborn death, or level 2 or 3 neonatal intensive care unit admission. Correlation was measured with Pearson *r*, and differences in risk between groups were examined using logistic regression.

**Results:** Among 1029 pregnancies with polyhydramnios, the diagnosis was based on DVP alone for 607 patients (59%), AFI alone for 75 patients (7%), and both methods for 347 patients (34%). AFI and DVP were moderately correlated ( $r = 0.56$ ). There were 32 perinatal deaths (3.1%). Compared with pregnancies diagnosed by DVP alone, pregnancies diagnosed by AFI alone had a higher risk of adverse perinatal outcomes (15% vs 29%, respectively; odds ratio [OR], 2.3; 95% confidence interval [CI], 1.3–3.9). The highest risk was observed in pregnancies diagnosed with both methods (33%; OR, 2.49; 95% CI, 2.0–3.7). Every 1-cm increase in AFI was associated with an 11% increase in odds of an adverse outcome (95% CI, 1.08–1.15), while DVP did not provide additional information on adverse outcomes above and beyond that obtained from AFI (OR, 1.04 per 1-cm increase in DVP; 95% CI, 0.91–1.19).

**Conclusions:** Pregnancies diagnosed with polyhydramnios based on AFI alone had a significantly higher risk of adverse perinatal outcomes compared with those diagnosed using DVP alone. AFI appears to be a better determinant of adverse perinatal outcomes in the context of polyhydramnios, and this measurement should be used to guide clinical decisions.

### 2352402 Factors Impacting Completion of the Low-Risk Obstetric Ultrasound Anatomic Survey

Brady Coad<sup>2,3</sup>, Grace Pariseau<sup>2,3</sup>, Grace Stocker<sup>2,3</sup>, Lisa Finch<sup>1,4,5\*</sup>

<sup>1</sup>Radiology, <sup>2</sup>Neurosciences Institute, Swedish Medical Center, Seattle, WA USA; <sup>3</sup>Gonzaga University, Spokane, WA USA; <sup>4</sup>OBX Seattle Ultrasound, Seattle, WA USA; <sup>5</sup>MEDNAX, Sunrise, FL USA

**Objectives:** The purpose of this study is to identify variables that are associated with incomplete visualization of fetal anatomy during midtrimester obstetric fetal surveys to help predict which factors are more likely to result in inadequate imaging. We hope to generate recommendations to increase efficiency and optimize conditions in order to reduce the rate of incomplete surveys.

**Methods:** Subjects were 372 pregnant women, ages 18–35 years, with gestational ages of 18–22 weeks. All subjects had a fetal survey during March–May 2015. Twelve data points from each subject's fetal survey were collected from patient charts: body mass index (BMI; kg/m<sup>2</sup>), gestational age (GA; weeks), maximum mechanical index (MI), maximum thermal index (TI), ultrasound machine used, location of exam, scanning sonographer, exam duration (minutes), whether all fetal anatomy was clearly seen, whether follow-up was required, and which anatomic parts (if any) were not well visualized. BMI groups were defined as  $\leq 22$  kg/m<sup>2</sup> (group 1), 22.1–25 kg/m<sup>2</sup> (group 2), 25.1–34.9 kg/m<sup>2</sup> (group 3), and  $\geq 35$  kg/m<sup>2</sup> (group 4). Statistical analyses included correlations and analyses of variance to examine factors that may have a significant relationship on surveys labeled incomplete ( $\alpha = .05$ ).

**Results:** The strongest predictor of inadequate visualization was the patient's BMI ( $r = .27$  total;  $P < .05$ ). Patients with higher BMIs tended to have longer exam times. Sonographer, performance site, MI, TI, GA, and exam time had no statistically significant relationship with incomplete surveys ( $P > .08$  for all). When covaried with BMI, physician had no statistically significant relationship with incomplete surveys.

**Conclusions:** After examining sonographer, physician, location, MI, TI, BMI, and GA, we can conclude that higher BMI was the only identified meaningful influence on inadequate ultrasound visualization of fetal anatomy. The likelihood of a fetal survey being adequate is higher in patients with a BMI in the group 1 and 2 range. This is one of many potential benefits of maintaining a healthy BMI.

Table 1. Complete Versus Incomplete Surveys in BMI Groups

BMI	Complete, %	Incomplete, %
<22	93.7	6.3
22.1–25	89.0	11.0
25.1–34.9	85.8	14.2
>35	56.0 <sup>a</sup>	44.0 <sup>a</sup>

<sup>a</sup> $P < .05$ .

### 2361584 Perimortem Demonstration and Treatment of Recipient-to-Donor Transfusion in Monochorionic Diamniotic Twin Gestation

Jessica Parrott, \* Carl Weiner

Obstetrics and Gynecology, Kansas University Medical Center, Kansas City, MO USA

**Objectives:** Twin-twin transfusion (TTTS) is a complication of monochorionic diamniotic (mo/di) placenta. If one twin dies, the cotwin suffers mortality/morbidity rates of  $\approx 30\%$ , each believed secondary to hemorrhage of the cotwin into the dying/dead twin. We report the apparently first ultrasound (US)-documented case of perimortem hemorrhage

and its treatment by emergent US-guided percutaneous cord occlusion followed by percutaneous fetal intravascular transfusion (IVT).

**Methods:** Case report.

**Results:** A 21 3/7-week G1P0 with mo/di twins was referred to the Kansas University Center for Advanced Fetal Care for TTTS. As the scan was initiated, terminal bradycardia (20 bpm) was seen in the presumed donor. Simultaneously, pulsatile blood flow was documented in the donor cord at the same rate as the recipient twin, whose middle cerebral artery (MCA) peak systolic velocity (PSV) was  $<1$  multiple of the median (MoM). The woman was rapidly transferred to the operating room, where a repeat US showed donor asystole but continued pulsatile cord blood flow originating from the recipient. The recipient's MCA PSV was still  $<1$  MoM. The now dead donor's cord was percutaneously occluded under US guidance (bipolar forceps). The time from the 1st scan with bradycardia to occlusion was  $<20$  minutes. US in the recovery room demonstrated a steadily declining heart rate (HR) in the surviving twin from 125 to 90 bpm over 10 minutes. US-guided percutaneous fetal intracardiac epinephrine (0.04 mg) was administered at 85 bpm and a fetal hematocrit (HCT) obtained. The fetal HR rapidly responded to epinephrine, and the HCT was 19%. Over the next 3.5 hours, the MCA PSV rose progressively to 2.56 MoM. A cordocentesis sample revealed an 18% HCT, and an emergent IVT restored the HCT to 36%. Routine US over the next 2 weeks showed an active survivor with pan-normal Doppler studies.

**Conclusions:** This case illustrates several important physiologic phenomena. One, the oft-stated acute fetal-to-fetal hemorrhage does occur and may begin before death. Delivery upon discovery is unlikely to protect the living twin. Two, the increase in the fetal MCA PSV due to acute anemia is relatively slow to develop at least prior to 22 weeks. Three, intracardiac epinephrine can correct acute fetal bradycardia due presumably to fetal hypotension.

### 2364223 An Uncommon Presentation to a Common Problem: Aborting Tubal Ectopic Pregnancy Presenting as an Ovarian Ectopic Pregnancy

Rami Farhat, \* Samia Sayegh, Sabrina Mahboob, Lisa David  
Radiology, Winthrop University Hospital, Mineola, NY USA

**Objectives:** Our objective is to describe how a common pathology such as a tubal ectopic pregnancy may present in complex fashion, mimicking a more rare entity on both diagnostic imaging and surgical exploration.

**Methods:** Our methods included a MEDLINE search on "ovarian pregnancy/ovarian ectopic pregnancy," "uncommon presentations of ectopic pregnancies," and "imaging of ectopic pregnancy." Relevant literature and recent guidelines on the management of ectopic pregnancies were reviewed.

**Results:** We present the case of a 32-year-old G1P0 female with no significant past medical history presenting with several days of vaginal spotting and mild abdominal cramping. On a pelvic sonogram, the patient was found to have a right ovarian ectopic pregnancy in the posterior cul-de-sac. The patient was subsequently sent to the operating room for laparoscopic surgical excision. On surgical exploration, a right ovarian ectopic pregnancy was identified, and the right adnexa was found tethered in the cul-de-sac. The ectopic pregnancy, right ovary, and right fallopian tube were removed. On pathologic examination, the gross appearance of the specimen was compatible with a right ovarian ectopic pregnancy. On microscopic examination, however, the tissue specimen revealed no implantation of the gestational sac within the ovarian parenchyma. Rather, the specimen was an aborting tubal ectopic pregnancy.

**Conclusions:** Ectopic pregnancies may occur in as high as 16% of women presenting to the emergency department with first-trimester bleeding. The vast majority of ectopic pregnancies ( $\approx 98\%$ ) occur in the fallopian tube. Other less common sites include the cervix, hysterotomy scar, ovary, and abdominal wall. Ovarian pregnancies are rare, occurring in

0.5% of ectopic pregnancies. This case demonstrates how a common pathology may present with similar findings and complications as a rarer entity. Although imaging and surgical findings were diagnostic for an ovarian ectopic pregnancy, the diagnosis of an aborting tubal ectopic pregnancy was only made following pathologic examination. Furthermore, rather than undergoing a routine salpingectomy or salpingostomy, our patient underwent an additional right oophorectomy.

#### 2369449 Twin Reversed Arterial Perfusion Sequence Treated by Aortic Sclerosis of the Acardiac Twin

**Mauricio Saito<sup>1</sup>, Juliana Martins<sup>1,2,\*</sup>, Daniela Pinheiro<sup>1</sup>, Kamille Said<sup>1</sup>, Debora Silva<sup>1</sup>, Rogerio Guidoni<sup>1</sup>**

<sup>1</sup>Conceptus, São Paulo, Brazil; <sup>2</sup>Obstetrics and Gynecology, University of Miami, Miami, FL USA

**Objectives:** The objective of this paper is to report 2 cases of twin reversed arterial perfusion (TRAP) sequence treated by aortic sclerosis of the acardiac twin with hypertonic glucose (50%) in early pregnancy.

**Methods:** TRAP sequence is a rare malformation associated with monozygotic/monochorionic twins where one twin (pump) develops normally and the other twin presents with severe anomalies, including an absent heart (acardiac), head, and body that will lead to its demise. The prognosis of the pump twin is also obscure, with a mortality rate ranging from 50% to 70%, mostly due to heart failure.

**Results:** From January 2011 to January 2013, 2 patients were referred to our department with an ultrasonographic diagnosis of TRAP sequence. Patients were primigravida in the early second trimester. Doppler identified the blood flow in the umbilical arteries toward the fetal abdomen of the acardiac twin (reverse of normal). In both cases, <10 mL of hypertonic glucose was infused into the fetal abdomen until cessation of aortic blood flow was identified by color Doppler. Steroids were administered at 28 weeks of gestation. In the first case, cesarean delivery was performed at 36 weeks (2560 g) due to premature rupture of membranes, and the baby's weight was 2560 g; the other pregnancy went to term, and the baby's weight was 3040 g. Both newborns were discharged from the hospital in good condition.

**Conclusions:** TRAP sequence is associated with polyhydramnios, congestive heart failure, fetal hydrops, and premature rupture of membranes. The mortality rate is approximately 50% to 70%. The essence of the treatment of TRAP sequence is interruption of the blood flow from the pump to the acardiac twin. Fetoscopic cord ligation or coagulation and laser or radiofrequency ablations of the acardiac twin vessels were described in previous studies. In early pregnancies, sclerosis of the acardiac fetal aorta with hypertonic glucose could be an alternative method of treatment for TRAP sequence. Larger prospective studies are necessary to validate this treatment option.

#### 2380731 Diurnal Changes in Fetal Umbilical Artery Blood Flow Parameters

**Tehila Avitan<sup>1,4,\*</sup>, Kenneth Lim<sup>1,4</sup>, Dan Rurak<sup>2,4</sup>, Meisan Brownlum<sup>3</sup>, Ursua Brain<sup>3,4</sup>, Tim Oberlander<sup>3,4</sup>**

<sup>1</sup>Maternal-Fetal Medicine, BC Women's Hospital, Vancouver, British Columbia, Canada; <sup>2</sup>Obstetrics and Gynecology, University of British Columbia, Vancouver, British Columbia, Canada; <sup>3</sup>Pediatrics, BC Children's Hospital, Vancouver, British Columbia, Canada; <sup>4</sup>Child and Family Research Institute, Vancouver, British Columbia, Canada

**Objectives:** To examine whether there are diurnal changes in fetal umbilical artery (UA) Doppler blood flow parameters in a normal population.

**Methods:** Prospective observational study. Singleton uncomplicated pregnancies between 35 and 36 weeks' gestation were recruited for this study. Patients with preexisting medical conditions, and/or taking

medications or drugs were excluded. Patients were placed in the left lateral decubitus position, and ultrasonography was performed by a single operator. UA Doppler parameters (systolic-to-diastolic ratio [S/D], pulsatility index [PI], and resistive index [RI]) were measured at 08:00 and then repeated 4.5 hours later following a structured rest period. All parameters were measured 5 times during fetal quiescence and in the absence of fetal breathing. The mean value was taken for analysis. Standard descriptive statistics and the Student *t* test (2 tailed) were used as appropriate. *P* < .01 was considered significant.

**Results:** Data for 45 subjects were obtained. Mean maternal age at the time of the study was 33.44 ± 4.47 years. Mean neonatal birth weight was 3536 ± 419 g. Mean gestational age at birth was 39.94 ± 1.12 weeks. There was significantly decreasing resistance to flow as measured by RI (0.62 vs 0.59; *P* < .01), PI (0.95 vs 0.88; *P* < .01), and S/D (2.69 vs 2.51; *P* < .01) between morning (AM) and afternoon (PM). Magnitudes of change were –5%, –7.5%, and –8.5%, respectively. There were no statistical differences in heart rate (HR) between AM and PM. Table 1 outlines the results.

**Conclusions:** In this study, we observed significant diurnal changes in UA Doppler flow parameters. The clinical implications of these findings are that when serial UA Doppler parameters are used to guide clinical management, consideration should be given to performing these measures at the same time of day to reduce the effect of diurnal variation.

Table 1. Comparison of UA Flow Characteristics: AM vs PM (n = 45)

	AM	PM	<i>P</i>
Fetal HR	135.50	133.09	.014
UA RI	0.62	0.59	<.01
UA PI	0.95	0.88	<.01
UA S/D	2.69	2.51	<.01

#### 2383165 Pregnant Women's Expectations and Perceptions of Ultrasound in Northern Tanzania

**Michael Bernaba,\* Samuel Kaplan, Jacqueline Kulwin, Kala Ghooray, Taylor Davis, Jamie Miller, Elisa Zhang, Maryte Gyls, Matthew Gunther, J. Christian Fox**

University of California Irvine, Newport Beach, CA USA

**Objectives:** (1) Does knowing about ultrasound influence the chance of receiving ultrasound? (2) Does the ultrasound examination meet the needs and expectations of the population? (3) Does the ultrasound examination make patients feel more/less stressed about the pregnancy? (4) How do demographics influence maternal attitude towards ultrasound?

**Methods:** Pregnant patients at Buzuraga Maternal Health clinic in Mwanza, Tanzania, and Ukerewe Hospital in Ukerewe, Tanzania, were asked to fill out a 21-question survey before a routine ultrasound examination. The survey contained questions about demographics and previous ultrasound experience. A routine ultrasound examination of the fetus was then performed. The patients were then asked to fill out a 5-question post-ultrasound survey.

**Results:** Although 68% of survey responders had heard of ultrasound, only 19.7% of survey responders had received an ultrasound examination before. The  $\chi^2$  test of independence *P* was .060114. As expected, there was also a direct relationship with the number of births a woman has given to the chance of receiving ultrasound before (*P* = .12728). The most common expectations of the ultrasound were to see if the fetus was alive (45%), to see that everything is all right (53%), to confirm the date of birth (DoB; 52%), and to identify gender (59%). Additionally, 91% of surgery responders felt good or very good during the examination, with 78% saying they had their expectations fulfilled with the ultrasound. In the end, 86% stated that they felt less worried about the pregnancy after the ultrasound examination. The most common methods of hearing of ultrasound were through friends/family (86%), medical pro-



professionals (78%), television (90%), newspapers (6%), and literature (6%).

**Conclusions:** The majority of women expected to receive specific information through the ultrasound examination, such as confirming DoB, identifying gender, or confirming twins, suggesting that the majority of women have well-defined expectations and are knowledgeable about the capabilities of ultrasound. In the end, we see that there is a clear desire for Tanzanian women to obtain information about their pregnancy. Ultrasound is a relatively low-cost imaging technique that can help alleviate pregnancy anxieties.

#### 2384955 The Effect of a Brief Ultrasound Training Session on the Proficiency of Medical Students in Obstetric Ultrasound Examination During a Core Clerkship

*Jasmine Fu,\* Elaine Hart, Reed Krause, Vi Am Dinh*

*School of Medicine, Loma Linda University, Fontana, CA USA*

**Objectives:** Many recent studies have shown the benefit of incorporating ultrasound training into medical school. However, time in the medical school curricula remains a prominent barrier to implementation. In this study, we aimed to discover the effects of a short, 1-time training session on the proficiency in bedside obstetric ultrasound exams in third-year medical students.

**Methods:** During the 2014–2015 academic year, third-year medical students were randomly assigned into an experimental group, which received a 15-minute training session, and a control group, which did not. The training session took place at the beginning of the students' obstetrics and gynecology clerkship and involved only 1 faculty member. These students were trained to identify the presenting part and measure the most vertical pocket and fetal heart rate. At the end of the clerkship, all students were tested and timed on their abilities to perform these exam maneuvers successfully. Survey data on ultrasound experience and exposure during the clerkship were also collected.

**Results:** A total of 86 third-year medical students (43 in each group) were included in the analysis. Across all tested variables, a higher percentage of the students who received the short training session were able to successfully identify ultrasound targets. Specifically, 90.7% of students in the trained group appropriately traced the fetal heart rate using "M-mode," while only 60.5% of students in the untrained group were able to complete this task ( $P = .0012$ ). Additionally, 74.4% of trained students versus 39.5% of untrained students were able to measure the fetal heart tracing from peak to peak or trough to trough ( $P = .0012$ ). The trained students spent an average of 27.1, 76.2, and 90.2 seconds compared to the untrained group, which utilized 38.2, 87.1, and 97.0 seconds to identify the presenting part ( $P = .03$ ), most vertical pocket ( $P = .17$ ), and fetal heart rate ( $P = .88$ ), respectively.

**Conclusions:** A brief, 1-time ultrasound training session can effectively enhance third-year medical students' proficiencies in bedside obstetric ultrasound exams during their core clerkship rotation.

#### 2385748 Does the Presence of Abnormal Umbilical Artery Doppler Findings at the Time of Detailed Ultrasound Predict Adverse Outcomes in the Advanced Maternal Age Population?

*Jessica Parrott,\* Emily Clark, Mark Holland*

*Obstetrics and Gynecology, Kansas University Medical Center, Kansas City, MO USA*

**Objectives:** Our goal was to determine if the finding of abnormal umbilical artery (UA) Dopplers in the advanced maternal age (AMA) population could be used to predict the occurrence of adverse outcomes in this population. Our secondary goal was to determine if AMA patients in our cohort had higher rates of adverse pregnancy outcomes after the exclusion of suspected aneuploid pregnancies.

**Methods:** A retrospective cohort study was conducted at a tertiary center from 7/2011 to 6/2014. Both AMA and non-AMA patients with abnormal UA Doppler flow at 18–22 weeks' gestation were identified

using our ultrasound database. Pregnancies complicated by multiple gestations, congenital fetal anomalies, and abnormal antenatal screening were excluded. Data regarding the pregnancy course were abstracted, including maternal age, demographic characteristics, medical complications, and perinatal complications. The Fisher exact test was used for analysis.

**Results:** One of 597 AMA cases was noted to have an abnormal UA Doppler (rate, 0.16%); 17/5582 non-AMA cases were identified as having elevated UA Doppler (rate, 0.30%), which was not statistically significant ( $P = .94$ ). There was a statistically significant difference in the rate of uterine artery notching (AMA 2.84% vs non-AMA 0%;  $P < .01$ ). AMA patients were noted to have a significantly increased risk of intrauterine growth restriction (AMA 3.69% vs non-AMA 0%;  $P < 0.01$ ), preterm birth (AMA 8.38% vs non-AMA 0.02%;  $P < .01$ ), neonatal intensive care unit admission (AMA 11.56% vs non-AMA 0.02%;  $P < .01$ ), and preeclampsia (AMA 4.52% vs non-AMA 0%;  $P < .01$ ). The rate of stillbirth in AMA (1.68%) vs non-AMA (0%) was not found to be statistically significant ( $P = 0.19$ ).

**Conclusions:** There was no statistically significant difference in the rate of abnormal UA Dopplers between AMA and non-AMA, indicating that AMA by itself is not a risk factor for abnormal UA Dopplers. The AMA population is at higher risk of multiple complications. Given the lack of a significant difference between abnormal UA Dopplers in AMA vs non-AMA populations, this does not appear to be a useful marker to predict that subgroup of AMA patients at high risk for adverse outcomes. An alternative screening strategy is needed.

#### 2385798 Is Second-Trimester Ultrasound Predictive of Extremes of Birth Weight?

*Terri-Ann Bennett,\* Margaret Dziadosz, Cara Dolin, Annie Honart, Sarah Pivo, Sara Lee, Ashley Roman*

*Obstetrics and Gynecology, New York University, New York, NY USA*

**Objectives:** To evaluate the utility of estimated fetal weight (EFW) percentile at routine 2nd-trimester ultrasound in the prediction of extremes of birth weight (BW) at the time of delivery.

**Methods:** This is a retrospective cohort of women with singleton gestations who underwent 2nd-trimester (16–24 weeks) ultrasound at a single practice from May 2014 to May 2015. The EFW percentile for gestational age was calculated using Hadlock 91. Intrauterine growth restriction/SGA was defined as <10th percentile for gestational age using Hadlock 91 at time of ultrasound or delivery. Large for gestational age (LGA) was defined as ≥90th percentile for gestational age at time of ultrasound or delivery. The percentile at 2nd-trimester ultrasound was compared with BW percentile at the time of delivery.  $\chi^2$  and Fisher exact tests were used where appropriate, with  $P < .05$  denoted as significance.

**Results:** A total of 929 women met criteria for inclusion. In our population, 14% of women delivered an SGA infant, and 4.4% delivered an LGA infant. Second-trimester EFW <10th percentile was associated with BW <10th percentile with a sensitivity of 2.9%, specificity of 99.6%, positive predictive value (PPV) of 57%, and negative predictive value (NPV) of 85% ( $P = .01$ ). In the assessment for LGA, a 2nd-trimester EFW ≥90th percentile had a sensitivity of 71%, specificity of 64%, PPV of 9%, and NPV of 98% ( $P < .001$ ).

**Conclusions:** While there is an association between extremes of EFW percentile at routine 2nd-trimester ultrasound and BW percentile, the association is weak, indicating that most growth abnormalities arise later in pregnancy. Patients found to be carrying an LGA fetus in the 2nd trimester can be reassured that the chance of LGA at delivery is <10%.

## Obstetric Ultrasound: New Techniques

### 2361889 Delayed Postpartum Decrease in Inferior Vena Caval Diameter in Women With Persistent Severe Preeclampsia Hypertension

*Celso Hernandez,\* Kathryn Reed, Wayne Cohen*

*University of Arizona, Tucson, AZ USA*

**Objectives:** To assess changes in the postpartum inferior vena caval (IVC) diameter and collapsibility index (CI) during the early postpartum period in women with severe preeclampsia (PE).

**Methods:** We studied 3 groups of women within 12 hours prior to and 12 hours after delivery. One group consisted of 5 normal gravidas; a second included 4 patients with severe PE with hypertension ( $>160/110$  mm Hg) that resolved promptly after delivery; the third consisted of 6 women with PE and severe hypertension that persisted postpartum. M-mode was used to measure the IVC diameter at end-inspiration and end-expiration. End-inspiration IVC diameter measurements were used for comparison. The CI was obtained by subtracting the difference between the end-expiratory and end-inspiratory values and dividing it over the end-expiratory IVC diameter.

**Results:** The groups did not differ in maternal age, body mass index, or parity. Gestational age was lowest in the PE group with persistent hypertension ( $26.4 \pm 3.9$  weeks) than the control group ( $31.2 \pm 3.8$  weeks) or those with resolved hypertension ( $33.3 \pm 3.8$  weeks;  $P = .04$ ). The predelivery IVC measurements were not different among the 3 groups. Comparison of these values with the postpartum measurements showed that the percentage change of the IVC diameter decreased significantly in the controls ( $-17.8\% \pm 7.8\%$ ;  $P = .0002$ ) and in the patients with resolving PE ( $-5.9\% \pm 7.2\%$ ;  $P = .017$ ) in comparison to the PE group with persistent hypertension, whose IVC diameter was increased over predelivery levels ( $11.2\% \pm 8.9\%$ ). There were no significant differences in the CI among the 3 groups.

**Conclusions:** Cardiovascular adaptations begin promptly after delivery, and previous studies have shown the expected reduction in blood volume is reflected in a decrease in the IVC diameter. We have confirmed this observation and shown that a similar change occurs in patients diagnosed with PE and hypertension that resolves promptly after delivery. However, in those women whose marked hypertension persisted after delivery, the fall in IVC diameter did not occur, probably a consequence of continuing vasospasm. Whether the use of IVC measurements would have some prognostic value in assessing the course of PE should be studied.

### 2384612 Comparing Uptake of Noninvasive Prenatal Testing at 2 Centers in Lebanon

*Reem Abu-Rustum<sup>1</sup>, \* Malek Nassar<sup>2</sup>, M. Fouad Ziade<sup>3</sup>*

*<sup>1</sup>Center for Advanced Fetal Care, Tripoli, Lebanon; <sup>2</sup>Centre de Diagnostic Prenatal, Zalka, Lebanon; <sup>3</sup>Faculty of Public Health, Lebanese University, Tripoli, Lebanon*

**Objectives:** Noninvasive prenatal testing (NIPT) using cell-free fetal DNA became available in Lebanon at the beginning of 2013. There are several cultural and religious beliefs that vary throughout the country affecting its uptake. As such, the aim of our study was to compare the uptake at 2 different areas of the country and to assess the patient demographics and testing indications.

**Methods:** Retrospective study on patients in our database at 2 centers in Lebanon (Centre de Diagnostic Prenatal [CDP] and Center for Advanced Fetal Care [CFAFC]) who underwent NIPT. All patients had undergone either first- or second-trimester ultrasound. The same counseling approach is adopted at both centers, where invasive testing/NIPT is offered to all patients over the age of 35 and to those with positive historical/sonographic/biochemical findings. In addition, it may be performed on patients who request it for reassurance following extensive counseling as to its advantages and limitations. All scans and counseling

were carried out by 2 sonologists certified by the Fetal Medicine Foundation. Outcome was available on all fetuses. Data were analyzed utilizing a  $\chi^2$  test.  $P < .05$  was considered significant.

**Results:** There were a total of 112 patients in the study. An NIPT result was available on 110/112 (98.2%) patients. There was 1 true-positive case (trisomy 21), 1 false-positive case (trisomy 18), and no false-negatives. Mean transport time was 3 days, and mean time from testing to a result was 9 days. There were 83/112 (74.4%) patients at CDP and 29/112 (25.6%) at CFAFC. The centers were similar in terms of patient age range; however, there was a statistically significant difference in the indications for testing primarily with respect to the presence of second-trimester soft markers ( $P = .001$ ), advanced maternal age ( $P = .024$ ), and an abnormal first-trimester scan ( $P = .044$ ). Based on the indications for testing, 51 patients would have been offered invasive testing.

**Conclusions:** Even in this small cohort of patients, our study attests to the acceptability of NIPT in our cultural setup in 2 areas of Lebanon. From our preliminary data, the primary indications for testing vary across the country. The national incorporation of NIPT into our patient population may avert a significant proportion of invasive tests on normal fetuses.

### 2385203 Comparison of the First-Trimester Transvaginal Anatomy Scan to the Second-Trimester Structural Survey in Obese and Nonobese Patient Populations: A Pilot Study

*Anna McCormick<sup>1,2</sup>, \* Ramkrishna Mehendale<sup>2</sup>, Heather Anaya<sup>2</sup>, Louis Fogg<sup>2</sup>, Michael Roche<sup>2</sup>, Jacques Abramowicz<sup>2</sup>*

*<sup>1</sup>Maternal-Fetal Medicine, Medical College of Wisconsin, Lake Bluff, IL USA; <sup>2</sup>Obstetrics and Gynecology, Rush University Medical Center, Chicago, IL USA*

**Objectives:** To compare accuracy of fetal anatomic transvaginal ultrasound (TVUS) done at 12–14 week's gestation to the traditional transabdominal ultrasound (TAU) for fetal anatomy at 18–22 weeks in normal-weight and obese patient populations.

**Methods:** In a prospective study, 26 women underwent TVUS for fetal anatomy evaluation between 12 and 14 weeks' gestational age and TAU at 18–22 weeks. The results of both scans were compared. The percentage of patients in which each structure was optimally visualized was calculated. The relative risk of visualizing a structure in the second trimester compared with the first was calculated in the sample groups.

**Results:** Twenty-six patients received the first-trimester TVUS, and 24 patients completed the TAU. The average body mass index (BMI) in the obese group was 34, and the average BMI for nonobese patients was 23. In all patients, all structures were more likely to be visualized during the TAU when compared to the TVUS. The cardiac views and hands and feet were more difficult to visualize at both scans but more frequently visualized during the TAU and were seen in 70%–80% of patients. In the obese patients, the posterior fossa, profile, hands and feet, cardiac views, and spine views were less likely to be visualized in the first trimester, but importantly, the cardiac structures and spine views were also difficult to view in this population at the time of the TAU. For the second-trimester scan, the cardiac views, hands and feet, and spine were also less frequently visualized in the obese patients.

**Conclusions:** First-trimester TVUS detects some of the structures assessed during a complete anatomic survey; however, this study shows that for obese and normal-weight patients, second-trimester TAU allows for better visualization. This study points out the need for additional imaging in obese patients. More research is needed to show if TVUS can be utilized for focused anatomy in the first trimester in this population.

## Obstetric Ultrasound: Uterus, Placenta, and Cervix

### 2378298 Fifth Recurrent Cesarean Scar Pregnancy

**Terri-Ann Bennett,\* Cara Dolin, Margaret Dziadosz, Ming Tsai, Judith Chervenak, Ana Montegudo, Ilan Timor-Tritsch**  
*Obstetrics and Gynecology, New York University Langone Medical Center, New York, NY USA*

**Objectives:** The increase in the cesarean delivery (CD) rate, from 5% in 1970 to 32.2% in 2014, has been associated with an increase in cesarean scar pregnancies (CSPs). The incidence of CSP is approximately 1 in 2500 CDs performed. There is currently no consensus on the optimal management of CSP or recurrent CSP. Our goal is to describe a patient with a fifth recurrent CSP who desired to continue the pregnancy.

**Methods:** The patient is a 35-year-old G7P2042 with 2 prior CDs and 4 prior CSPs with a positive fetal heart rate, treated with intragastric injection of methotrexate. A GE Voluson E8 (Milwaukee, WI) transabdominal and transvaginal ultrasound system was used to perform serial 2D and 3D renderings. A live CSP was diagnosed on the initial scan at 8 4/7 weeks; the gestational sac was noted to be at the cesarean scar niche with a mostly posterior placenta previa that also wrapped around anteriorly to the level of the bladder. The placenta had multiple lacunae and hypervascularity by 11 4/7 weeks, and a morbidly adherent placenta (MAP) was suspected. A placenta percreta was assumed by 17 4/7 weeks. Magnetic resonance imaging was performed at 32 2/7 weeks, with an impression of placenta previa with increta.

**Results:** Maternal-fetal medicine specialists counseled and followed this patient throughout the pregnancy. An outpatient betamethasone course was given 48 hours prior to scheduled cesarean hysterectomy with Gynecologic Oncology backup. Urology was consulted preoperatively and placed ureteral stents. At 34 0/7 weeks, the patient underwent a cesarean hysterectomy with bilateral salpingectomy. The pathology confirmed a MAP: placenta percreta. She did well postoperatively and was discharged home on postoperative day 3. The neonate was small for gestational age and was discharged home from the neonatal intensive care unit on day 9 of life.

**Conclusions:** CSP is a rare pregnancy complication of CD, and its frequency is mirroring the increasing CD rates. Recurrent CSPs are even more infrequent, and a fifth repeat as in our patient has not been previously described. This case adds more to the mounting data that CSP is a precursor to MAP. Additionally, it displays how the counseling of CSP has shifted over time, indicating that patients with CSP can be offered continuation of pregnancy with understanding of the maternal risks, including uterine rupture and cesarean hysterectomy for MAP.

## Pediatric Ultrasound

### 2374890 Diagnosis of Appendicitis With Point-of-Care Ultrasonography in Children: A Retrospective Review

**Kay Odashima,\* Eitan Dickman, Francis See, Emin Elezi, Samuel Kluger, Sean McGann, Marla Levine, Lawrence Haines, Mark Tessaro**  
*Emergency Medicine, Maimonides Medical Center, Brooklyn, NY USA*

**Objectives:** To determine the test characteristics of pediatric emergency medicine (PEM) physician-performed point-of-care ultrasonography (POCUS) for the diagnosis of appendicitis and to report differences in time to disposition between patients who received POCUS and those who did not.

**Methods:** We performed a single-center retrospective chart review of all pediatric emergency patients who were evaluated for possible appendicitis over a 4-year period. Patients were enrolled in the POCUS arm if: (1) POCUS by a PEM physician was performed; (2) the images were stored and available for review; and (3) the POCUS impression was documented

in the chart. Test characteristics of POCUS for the diagnosis of appendicitis were the primary outcome measures. Secondary outcome measures included: (1) time elapsed between POCUS and the result of radiology department imaging; (2) time elapsed from emergency department arrival to the results of radiology department imaging, compared between patients who received POCUS and those who did not; and (3) time to disposition compared between patients who received POCUS and those who did not.

**Results:** A total of 7511 charts were reviewed, of which 91 met inclusion into the POCUS arm. Mean age was 10.7 years with a range of 21 months to 17 years. Thirty-six (40%) of patients were female. POCUS was 91% sensitive and 87% specific for the detection of appendicitis with a positive predictive value of 87% and a negative predictive value of 91%. The positive likelihood ratio was 7, and the negative likelihood ratio was 0.1. The average times elapsed between POCUS and radiology US and computed tomography (CT) preliminary reads were 126 and 353 minutes, respectively. It took an average of 55 and 38 minutes longer for the radiology US and CT preliminary reads, respectively, for patients who received POCUS compared to those who did not. However, the time from arrival to disposition was 62 minutes shorter in patients who received POCUS compared to those who did not.

**Conclusions:** POCUS performed by PEM physicians for the diagnosis of appendicitis has a specificity and positive predictive value comparable to US performed by radiologists. Though the times to radiology studies were longer for patients receiving POCUS, the use of POCUS was associated with a faster time to disposition.

### 2377786 Effect of Ultrasound as an Initial Imaging Modality in Children With Suspected Appendicitis

**Stephen Alerhand,\* Ee Tay**  
*Emergency Medicine, Icahn School of Medicine at Mount Sinai, New York, NY USA*

**Objectives:** Computed tomography (CT) has traditionally been the initial diagnostic modality for detecting appendicitis. Recent studies point to the use of ultrasound (US) in children due to the lack of radiation. Using US first may decrease the overall length of stay in cases with diagnostic results. In cases with nondiagnostic US, however, CT is often performed afterward. This increases the length of stay and may contribute to disease progression. The objective of this study was to evaluate whether US as an initial imaging modality increases complication rates in children with appendicitis.

**Methods:** Retrospective review was performed for children  $\leq 17$  years old diagnosed with appendicitis in 2 urban pediatric emergency departments. Patients with known perforation, outside transfers, and non-operative cases were excluded. Patients with US as their initial imaging modality were compared to those with CT only. Complication rates and time from triage to surgical incision were measured. Complications were defined as 1 or more of the following: perforated/gangrenous appendix on surgical/pathology reports; and pertinent medical visits, radiology studies, and/or procedures performed within 6 months after appendectomy. Time to appendectomy was expressed using medians and interquartile ranges (IQRs). Mann-Whitney tests were used where appropriate.

**Results:** Of 1411 charts reviewed, 661 patients (47%) were eligible for analysis. Those with US performed initially were not at increased odds of experiencing a complication (27.1%) compared to the CT-only group (27.7%; odds ratio [OR], 0.98; 95% confidence interval [CI], 0.70–1.38). Time (minutes) to appendectomy was not significantly different between the US group (553 [IQR, 385, 846]) and the CT-only group (594 [IQR, 437, 797];  $P = .24$ ). Of patients in the US group, 103 (28.8%) underwent a subsequent CT scan. This subgroup, compared to the CT-only group, had a greater time to appendectomy (867 [IQR 604.5, 1149.55];  $P < .01$ ) but was not more likely to experience a complication (28.2%; OR, 1.02; 95% CI, 0.62–1.68).

**Conclusions:** Performing US followed by CT does not increase the complication rate compared with performing US or CT alone. Thus, US should be offered as the initial imaging modality due to its safety features.



**2385744 The Effect of Point-of-Care Ultrasound on Emergency Department Diagnosis and Management of Cellulitis Versus Local Allergic Reactions From Insect Bites**  
**Jennifer Sanders,\* Ee Tay**

*Pediatric Emergency Department, Icahn School of Medicine at Mount Sinai, New York, NY USA*

**Objectives:** The sonographic findings of cellulitis have been well described, but to date, only a small case series can be found that describes the appearance of allergic reactions/angioedema from insect bites. Our objective was to evaluate the effect of soft tissue ultrasound (US) on management of soft tissue swelling in emergency department (ED) patients with insect bites.

**Methods:** This was a prospective study in a pediatric ED of patients  $\leq 21$  years old, with clinical soft tissue swelling from insect bites. Treating physician's pretest opinions regarding the diagnosis and need for antibiotics (ABX) were determined. Trained ED physicians performed US of the affected area, and the effect on the management plan was recorded. We defined cellulitis on US as thickened skin and the presence of soft tissue lobules with surrounding fluid, known as "cobblestones." Angioedema was defined as the presence of multiple, linear, horizontal, and striated hypochoic bands within the tissue. Further imaging, medications, and disposition were at the discretion of the enrolling physician. Phone call follow-up was made within a week of the initial presentation.

**Results:** Among 103 enrolled patients, 16 had cellulitis (15.5%). Mean age was 7 years ( $\pm 6$  years); 50.5% were male. US changed the management of patients with soft tissue swelling secondary to insect bites in 27/103 (26%; 95% confidence interval [CI] 18% to 35%) patients. Of the patients who were believed to require ABX prior to the test, US changed management in 6/26 (23%; 95% CI, 6% to 40%) patients. In those patients who were not believed to require ABX prior to the test, US changed management in 12/77 (16%; 95% CI, 7% to 24%). On average, patients with a diagnosis of an acute reaction (AR) achieved symptom resolution 1.4 days sooner than patients with a diagnosis of cellulitis (mean,  $-1.389$ ; 95% CI,  $-2.094$  to  $-0.705$ ;  $P < .001$ ). No patient diagnosed with AR subsequently required ABX upon the follow-up visit.

**Conclusions:** Soft tissue US changes physician management in approximately 25% of patients in the ED with soft tissue swelling secondary to insect bites and may improve recognition of early cellulitis.

**2386986 Beware! Inguinolabial Hernia Containing Reproductive Organs in Female Children Is Not as Rare as You Think**  
**Anjum Bandarkar,\* Eglal Shalaby-Rana, Adekunmi Adeyiga**  
*Radiology, Children's National Health System, Herndon, VA USA*

**Objectives:** (1) Review differential diagnoses of groin swelling in girls  $< 2$  years of age. (2) Describe sonographic appearances and frequency of ovary-, fallopian tube-, and uterus-containing inguinolabial hernias.

**Methods:** Using a radiology search engine, we retrospectively reviewed 38 female children  $< 2$  years of age who underwent sonography for groin swelling. Their clinical presentation, sonographic imaging features, and intraoperative findings were recorded.

**Results:** Thirty-one patients (82%) had inguinal hernias. Of note, 10 patients in this group were premature infants. Seven patients (18%) had other etiologies, which included: (1) abscess ( $n = 3$ ), (2) lymphadenopathy/cellulitis ( $n = 3$ ), and (3) canal of Nuck hydrocele ( $n = 1$ ). Thirty-one of the 38 patients (82%) had inguinal hernias; 26 patients (84%) had hernias containing female reproductive organs. Seventeen had ovary and/or fallopian tube in the hernia sac; 9 patients also had uterus in the hernia sac. Four patients (13%) had hernias with male gonads, either atrophic testes or ovotestes, later proven to have androgen insensitivity syndrome. One patient (3%) had a hernia containing bowel. A correct

sonographic diagnosis was made prospectively in 36/38 patients. Missed findings were identified retrospectively in 2 patients, in whom the contents of the inguinal hernia were called bowel/omentum instead of ovary. Vascular compromise of the ovary was present in 1 patient, and it was prospectively identified. All of the inguinal hernia cases were successfully repaired with favorable outcomes.

**Conclusions:** Inguinal hernia is the most common cause of groin swelling in young female children, with premature infants comprising one-third of the group. Ovary and/or fallopian tube and sometimes uterus are the most common contents of the hernia sac. Infrequently, testis may be present in the hernia sac/labia, a cue to the diagnosis of androgen insensitivity syndrome. Bowel is rarely seen as contents of the hernia sac in female infants. Sonography easily and accurately depicts the contents of the hernia and may add valuable information such as vascular compromise. Sonography also helps exclude other causes of inguinolabial swelling and hence should be included in the diagnostic and preoperative workup of patients with groin swelling.

**2388097 Prediction of High-Grade Vesicoureteral Reflux in Children Younger Than 2 Years Using Renal Ultrasonography: A Preliminary Study**  
**Sun You, Kyung-Sook Shin**  
*Radiology, Chungnam National University Hospital, Daejeon, Korea*

**Objectives:** To investigate the predictive value of renal ultrasonography (US) for vesicoureteral reflux (VUR) and the efficacy of renal US, technetium 99m-labeled dimercaptosuccinic acid (DMSA) scanning, and a combination of the two for VUR screening in children under 2 years of age with a first episode of febrile urinary tract infection (UTI).

**Methods:** Thirty-eight patients under 2 years of age with a first febrile UTI were included in our study, which was conducted from April through October 2014. Each kidney was considered as a separate renal unit (RU). A retrospective review of clinical information and images (renal US, DMSA scanning, and voiding cystourethrography) was performed.

**Results:** Of the 14 RUs (18.4%) with VUR, 4 (28.5%) had high-grade VUR. Among single findings, dilation of the renal collecting system (DRCS), wall thickening of the renal collecting system (WTRCS), and DMSA scans significantly predicted VUR ( $P = .038$ ,  $.027$ , and  $.01$ , respectively). DRCS was the most common single finding (46 of 76 renal units). The sensitivities of DRCS, WTRCS, and DMSA scans were 85.7%, 64.2%, and 50.0%, respectively, and the negative predictive values were 93.3%, 89.7%, and 87.9%, respectively.

**Conclusions:** The negative predictive values indicate that normal renal US and DMSA scans can predict the absence of high-grade VUR. We propose that renal US findings of WTRCS, as well as DRCS, should be considered predictive of high-grade VUR.

## Sonography: Education and Training

**2348321 Peer-Assisted Learning: A New Model for Medical School Ultrasound Education**  
**Ben Lasure,\* Brian Dilcher, Joseph Minardi**  
*Emergency Medicine, West Virginia University School of Medicine, Morgantown, WV USA*

**Objectives:** To examine the utility of near-peer-assisted learning in medical school ultrasound education.

**Methods:** The coinvestigators created a review lecture based on the curriculum and practical rubric. Students were provided with objectives prior to the review session to assess its effectiveness in a voluntary and anonymous postsession survey. This demonstration consisted of 2 West Virginia University (WVU) peer-assisted learning strategy (PALS) tutors giving a 45-minute didactic review. Next, the floor was opened for

question-and-answer demonstrations lasting 15 minutes. At this point, the students were divided among 7 stations equipped with the same ultrasound machines that would be used for their practical examination. Within the groups, the first-year medical students took turns being models while their peers scanned, and the 2 PALS tutors rotated through the groups to provide direction. The small-group session lasted for 2 hours. The surveys were collected, and data and student comments were compiled to evaluate session efficacy. This session was run entirely by 2 WVU PALS second-year medical student tutors without instructor intervention.

**Results:** Over 60 first-year medical students attended the voluntary Saturday morning lecture 2 days before their anatomy exam and 4 days before their ultrasound practical. Fifty-four students signed in, and 34 took the postsession survey. The student response to the session was overwhelmingly positive, with one of the most frequently written comments being that WVU PALS should provide more similar sessions throughout the year. Other suggestions included that the session be broken into smaller groups with more tutors for a lower student:tutor ratio. Thirty-three of 34 responses reported that the session met the stated goals; 34/34 reported that the session was useful to improve ultrasound skills; 32/34 reported that the session helped them feel more comfortable with their scanning skills; and 33/34 reported that they would like to have more similar sessions in the future.

**Conclusions:** The review session was deemed successful, with good student turnout, positive evaluations, and interest in future sessions. Near-peer tutoring is a new and promising approach to medical school ultrasound education in the hands of skilled users.

**2366866 The Neck Is More Than the Thyroid Alone: 3-Dimensional Ultrasound of Cervical Lymph Nodes, Salivary and Parathyroid Glands, and Palpable/Visible Abnormalities**  
*Susan Frank<sup>1,2</sup>, \*David Gutman<sup>1</sup>, Tova Koenigsberg<sup>1,2</sup>*

<sup>1</sup>Radiology, Montefiore Medical Center, Park Ridge, NJ USA;

<sup>2</sup>Radiology, Albert Einstein College of Medicine, Bronx, NY USA

**Objectives:** Ultrasound (US) imaging is helpful in evaluation of the neck in many clinical situations. The potential benefits of 3DUS when added to 2DUS will be explored in the following situations: cervical lymph node evaluation, including but not limited to post-thyroidectomy lymph node evaluation; parathyroid gland evaluation in patients with primary and secondary hyperparathyroidism; salivary gland evaluation for small masses and sialolithiasis; and evaluation of palpable/visible abnormalities.

**Methods:** Table of Contents/Outline: Normal 3DUS appearance of cervical lymph nodes, both grayscale and color Doppler. Normal appearance of the salivary glands. Normal appearance of the parathyroid glands. Atlas of 3D US of reactive lymph nodes and of lymph nodes with metastatic disease. Atlas of 3DUS of parathyroid adenomas/hyperplasia, primary and secondary. Atlas of 3DUS of various salivary gland abnormalities, including but not limited to: sialolithiasis and assorted benign and malignant lesions.

**Results:** Additional information provided by 3DUS compared with 2DUS is illustrated in varied clinical applications, including the evaluation of cervical lymph nodes after thyroidectomy, the evaluation of the salivary glands in patients with pain or palpable abnormalities, the evaluation of the parathyroid glands in patients with primary hyperparathyroidism, and the evaluation of palpable or visible neck abnormalities.

**Conclusions:** 3DUS is not yet widely used for assessment of the neck aside from the thyroid gland, but initial experiences indicate that it may prove to be a powerful technique for a variety of clinical indications.

**2363910 Integration of Head and Neck Ultrasound Into the First-Year Medical School Curriculum: A Pilot Study**

*Jane Dyball\*, Michael Prats, David Bahner*

*Ohio State University College of Medicine, Columbus, OH USA*

**Objectives:** To assess the feasibility and outcomes of introducing head and neck ultrasound into the first-year medical school curriculum to improve anatomic knowledge and understanding of ultrasound applications.

**Methods:** This is a pilot study of 45 first-year medical students. Students were recruited on a voluntary basis to attend a 2-hour didactic in head and neck ultrasound. The session was designed to complement the traditional teaching of head and neck anatomy by incorporating ultrasound education regarding the relevant anatomic structures. The session began with a basic overview of transducers and knobology. The topics covered included examination of the thyroid gland, identification of sites for percutaneous tracheostomy, identification of the vascular structures of the neck for vascular access, and visualization of the optic structures with estimation of intraocular pressure. After a short lecture, all students were given the opportunity to practice the scans on student models and phantoms. At the conclusion of the session, students were asked to evaluate their experience via a short anonymous survey.

**Results:** Fourteen students responded to the survey (14/45 [31.1%]). All students either “agreed” or “strongly agreed” that the lecture and hands-on scanning time met their learning needs, was relevant to their coursework, and was an effective adjunct to that coursework. They similarly felt that the session gave them a better understanding of anatomy and the clinical utility of ultrasound. All students stated that as a result of this experience, they will participate in future ultrasound events and encourage their peers to do the same. All but 1 respondent agreed that this ultrasound session should be integrated into the medical school curriculum.

**Conclusions:** This pilot study demonstrates that integration of head and neck ultrasound sessions into the medical school curriculum is both feasible and beneficial, as evidenced by the markedly positive response from student participants. Further studies will be necessary to more clearly define the content, length, and teaching modalities (didactic vs hands-on) of such sessions that are most appropriate for first-year medical students’ learning needs.

**2370570 Development of 8 Ultrasoundable Intraocular Pathology Phantoms Designed for Resident Education**

*Chelsee Allen<sup>1</sup>, \*Anthony Trace<sup>2</sup>, Luke Moore<sup>3</sup>, Shannon McCole<sup>3</sup>, Craig Goodmurphy<sup>4</sup>, Carrie Elzie<sup>4</sup>*

<sup>1</sup>School of Medicine, <sup>2</sup>Radiology, <sup>3</sup>Ophthalmology, <sup>4</sup>Pathology and Anatomy, Eastern Virginia Medical School, Norfolk, VA USA

**Objectives:** Ultrasound is an effective and efficient diagnostic tool for assessing intraocular pathologies. Currently, available ocular phantoms have limited shelf life and limited diversity of constructed pathologies. A notable portion of resident training is “on the job,” which is restricted by the number of specific pathologic patient encounters, time constraints, and instructor biases. To ameliorate this, we constructed inexpensive and durable phantoms to train residents in the recognition of 8 intraocular pathologies using ultrasound.

**Methods:** The normal ocular phantom consists of vinyl rubber, an epoxy lens, and a radio-dense surgical string; modifications were employed to construct 8 pathologies (choroidal effusion, retinal detachment, posterior vitreous detachment, posterior staphyloma, posterior scleritis, foreign body, melanoma, and retinoblastoma). A pretest, online training module, and posttest will assess the phantoms’ abilities to aid in training residents in ocular pathology diagnosis using ultrasound.

**Results:** Attending emergency medicine and ophthalmology physicians have reviewed the phantoms for suitability and clinical refinement. Questionnaire feedback indicates that the training phantoms are

cost-effective, are durable, and have suitable fidelity for training clinicians in ophthalmologic ultrasound. Resident pre and post testing demonstrates an overall improvement in ultrasound-guided identification of intraocular pathologies.

**Conclusions:** The utilization of these phantom trainers is a cost-effective tool that allows self-paced clinical and technical training of ocular ultrasonography and assessment of relatively common intraocular pathologies. Future studies will focus on widening the scope of the study to other residency programs within ophthalmology as well as emergency medicine.

### 2377851 Ultrasound-Guided Nodal Localization for Targeted Radiation Therapy in Breast Cancer Patients

*Ezinne Lawson<sup>1,2</sup>, \* Benjamin Smith<sup>2</sup>, Deanna Lane<sup>2</sup>, Mark Dryden<sup>2</sup>, Gary Whitman<sup>2</sup>*

<sup>1</sup>Diagnostic Radiology, University of Texas, Houston, TX USA;

<sup>2</sup>Radiology, M. D. Anderson Cancer Center, Houston, TX USA

**Objectives:** The implementation of computed tomography (CT)-guided radiation treatment planning has resulted in greater precision in dose distribution, optimization, and patient positioning. However, limitations such as suboptimal tissue contrast and limited visualization of small tumor deposits/nodal disease persists and can sometimes preclude inclusion of locoregional metastasis for radiation. Real-time ultrasound scanning has good tissue contrast and can visualize small tumors and small lymph nodes while the patient is positioned in the same configuration used during radiation therapy. Ultrasound is also radiation free, does not require contrast, and is relatively quick to perform. To our knowledge, there is no published work on marking suspicious or proven malignant supraclavicular, infraclavicular, or lower neck nodes for inclusion in radiation therapy in breast cancer patients. This study highlights the use of ultrasound as an adjunctive tool during radiation therapy planning to detect small residual nodal disease for inclusion in the radiation field of breast cancer patients after breast surgery.

**Methods:** In this method of nodal localization, suspicious supraclavicular, infraclavicular, and lower neck adenopathy are identified by real-time ultrasound scanning. The site/s is/are marked on the skin using a BB or surgical marker, and the distance from the skin surface to the node/tumor implant is recorded. The patient is transported back to the radiation oncology suite for completion of CT-guided radiation planning.

**Results:** We show the successful use of ultrasound-guided nodal localization to identify and mark suspicious nodes in breast cancer patients for definitive inclusion in the radiation field.

**Conclusions:** Real-time ultrasound scanning is a safe and accurate method of detecting small-volume superficial disease, which can be marked, included, and targeted for radiation therapy in the hopes of improving patient outcomes and decreasing the residual disease burden. We highlight the use of ultrasound for directed supraclavicular, infraclavicular, or lower neck nodal localization for inclusion in the radiation field in breast cancer patients with residual nodal disease following breast surgery.

### 2383103 Continued Optimization of a Sustainable Clinical Ultrasound Curriculum in Mwanza, Tanzania

*Samuel Kaplan, \* Morgan Kendall, Jamie Miller, Michael Bernaba, Taylor Davis, Kala Ghooray, Matthew Gunther, Maryte Gylys, Jacqueline Kulvin, Elisa Zhang, J. Christian Fox*  
University of California Irvine School of Medicine, Irvine, CA USA

**Objectives:** Continue to develop and refine an introductory clinical ultrasound curriculum that is pertinent, time-efficient, retainable, and sustainable for Tanzanian health care students.

**Methods:** Revamped curriculum introduced by University of California Irvine School of Medicine (UCISOM) teams in 2013 and 2014, including a 3-week course at Tandabui Institute, Mwanza, Tanzania for 68 clinical officer students in June 2015; an integrated basic pathology

unit with introductory ultrasound; and a total of 6.5 hours of lecture and ~20 hours of hands-on practice. Topics include “knobology,” cardiac, pulmonary, focused assessment with sonography for trauma, abdominal, obstetric/pelvic exams, and related pathology. Important outcomes were measured based on cumulative course scores; analysis of variance of pretest vs posttest (identical content/difficulty) and prior ultrasound experience vs inexperience; and precourse and postcourse surveys with Likert feedback scales and free-response fields. Results: (1) Seventy-one percent of students had no prior ultrasound experience; 26% had observed it in clinics, and 3% had taken another course. (2) Overall mean score improvement (pretest vs posttest): 39.7%; for inexperienced only: 37.8%; for experienced only: 45.9%. No significant effect of experience on pretest/posttest means. (3) Sixty-five (95.6%) of 68 students passed the course. (4) Comfort with the abdominal exam was highest (4.8 out of 5), pathology lowest (4.2 out of 5). (5) Most useful resource: hands-on small-group sessions. (6) The pathology unit was rated 4.48 out of 5 in helpfulness to the learning experience. (7) Most popular responses: increase amount of hands-on time, increase pathology coverage, and introduce multiyear course sequence.

**Conclusions:** Despite logistical, financial, linguistic, and intercultural challenges, measures point to success by UCISOM in developing a sustainable, efficient, and pertinent curriculum. The course pass rate was high. Lack of prior experience did not demonstrably impair students’ ability to score proficiently. Provided resources were rated highly. Feedback supports the course model with pathology integrated with “normal” ultrasound. Future considerations: increased hands-on time, broader pathology coverage, multiyear curriculum, smaller student-to-instructor ratio. With increasing demand for efficient, noninvasive diagnostic techniques like ultrasound, UCISOM has helped set an important precedent in international medical education.

### 2384827 Utilizing a Multimodal Approach in Teaching Medical Students Ultrasound-Guided Procedures

*Cassandra Krause, \* Reed Krause, Michael Douglas, Vi Am Dinh*

Loma Linda University, Loma Linda, CA USA

**Objectives:** Formal ultrasound education has been incorporated into several medical schools across the country, but few are teaching students how to perform ultrasound-guided procedures. The purpose of this study was to assess the effectiveness of a 50-minute ultrasound-guided procedural training module for medical students utilizing a multimodal approach.

**Methods:** This was a self-controlled prospective observational cohort study. The ultrasound-guided procedural training module was taught at our institution’s 2015 Ultrafest ultrasound symposium. We assessed participants’ comfort level with ultrasound using a preliminary event survey and a postevent survey. The training included 15 minutes of didactics and 35 minutes of hands-on training utilizing simulation mannequins. The ultrasound-guided procedures taught were: peripheral vascular access, lumbar puncture, thoracentesis, needle biopsy, and central line access. Comparisons were analyzed with the Wilcoxon signed rank test.

**Results:** Fifty-three participants from 6 medical and osteopathic schools in Southern California completed both preliminary and postevent surveys using a 5-point Likert scale. In each procedure, there was statistically significant improvement in confidence of the participant’s overall technique ( $P < .0001$ ), ability to identify pertinent anatomy ( $P < .05$ ), ability to track the tip of the needle to avoid puncturing nearby anatomic structures ( $P < .0001$ ), and ability to perform each procedure on a real patient ( $P < .0001$ ). After the training, 96% of the participants agreed or strongly agreed that ultrasound procedural training should be incorporated into their medical school’s curriculum.

**Conclusions:** This study supports the value of incorporating procedural training into undergraduate medical education.



**2385030 Advanced Competency in Ultrasound for Undergraduate Medical Education**

Ross McDermott<sup>1</sup>,\* Marcia Bockbrader<sup>2</sup>, Krystin Bachman<sup>1</sup>, David Bahner<sup>3</sup>

<sup>1</sup>Ohio State University College of Medicine, Columbus, OH USA; <sup>2</sup>Physical Medicine and Rehabilitation, <sup>3</sup>Emergency Medicine, Wexner Medical Center at Ohio State University, Columbus, OH USA

**Objectives:** To define a framework for advanced competency in ultrasound (US) in undergraduate medical education (UME).

**Methods:** Elements of advanced competency were developed based on institutional practices of an established longitudinal US program (Bahner and Royall, 2013), local medical school curricular requirements for formal “advanced competency,” best practices for vertical US curricula, and literature describing teaching and evaluation of US trainees (I-AIM: Bahner et al, 2012; B-QUIET: Bahner et al, 2011).

**Results:** Advanced competency in US at the UME level is defined as the conceptual knowledge, psychomotor technical skills, and professional practice improvement skills and attitudes necessary for performing ultrasound in clinical settings. Table 1 describes criteria in each key competency area for attaining Advanced Competency, Advanced Competency With Distinction, and Advanced Competency With Honors. Conceptual knowledge covers ultrasound physics, tissue characteristics, instrumentation, anatomy and physiology, indications, and protocols. Scanning skill is demonstrated through compilation of a scan portfolio, a portion of which must be clinical and must pass faculty quality review using B-QUIET. Practice improvement includes lifelong learning skills and evaluation of new ultrasound knowledge. Specific content may be tailored based on institutional resources and student interests. Feasibility of the framework has been established by honors US students at the Ohio State University College of Medicine who achieved these requirements during their UME training.

**Conclusions:** Advanced competency denotes focused knowledge, skills, and attitudes beyond the general UME curriculum intended to have immediate clinical significance on entering residency. This abstract describes a framework for advanced competency in US at the UME level that is flexible, is achievable, provides clinically relevant skills for clerkships and residency, and is generalizable to other institutions.

Table 1. Advanced Competency Criteria

#### Requirements

##### Advanced Competency

###### *Conceptual knowledge*

>150 h in supervised US curriculum topics

###### *Scanning skill*

Log of 50 scans (>10 clinical, >50% clinical scans pass B-QUIET faculty review)

###### *Practice improvement*

>10 h of participation in physician-led journal club

##### Advanced Competency With Distinction

###### *Conceptual knowledge*

Above + advanced specialty-specific topics

###### *Scanning skill*

Log of 100 scans (>20 clinical, >50% clinical scans pass B-QUIET faculty review)

###### *Practice improvement*

Above + authorship on abstract presented at national conference

##### Advanced Competency With Honors

###### *Conceptual knowledge*

Above + teaches above

###### *Scanning skill*

Log of 150 scans (>30 clinical, >50% clinical scans pass B-QUIET faculty review)

###### *Practice improvement*

Above + authorship on manuscript published in academic journal

#### **2385291 Evaluation of Sophomore Medical Students' Competencies in Image Recognition and Interpretation of Ultrasound Pathology: An Innovative Ultrasound Curriculum Developed at the Wayne State University School of Medicine**

David Amponsah

Emergency Medicine, Henry Ford Hospital, Detroit, MI USA; Wayne State University School of Medicine, Detroit, MI USA

**Objectives:** Ultrasound education was first incorporated into the Wayne State University School of Medicine (WSUSOM) undergraduate curricula in 2006. Sophomore students demonstrate skills in image capture, recognition, and interpretation of ultrasound pathology as part of their physical diagnosis final exam. The goals of this study are: (1) to provide a description of the sophomore ultrasound curriculum; (2) to determine how well students perform on the final exam after introduction to ultrasound pathology; and (3) to evaluate student performance since 2013 for improvement in scores with modification to instructional methods.

**Methods:** An average of 288 medical students during their sophomore year at WSUSOM receive instruction on image recognition and interpretation of ultrasound pathology using a case-based approach to teaching. Students also enhance their image acquisition skills using standardized patients with an instructor-to-student ratio of 1:4. Sessions include an in-class image review of ultrasound pathology and a debriefing session focusing on presentation and discussion of clinical cases. The final exam includes an image capture portion and a computer-based 10-item multiple-choice exam with embedded video clips focusing on recognition and interpretation of ultrasound pathology.

**Results:** Average scores from 2011–2015 are as follows: academic year 2011–2012, 280 students; mean score, 76.5%; academic year 2012–2013, 300 students; mean score, 74.4%; academic year 2013–2014, 285 students; mean score, 81.7%; academic year 2014–2015, 290 students; mean score, 80.8%. Students also performed very well in their image capture portion (6-second video clips) of the final exam, with mean scores of 89.3% and 85.1% for the 2013–2014 and 2014–2015 academic years, respectively.

**Conclusions:** Developing innovative teaching methods since 2013 during the sophomore ultrasound course has resulted in improvement in student scores in their image acquisition skills and recognition and interpretation of ultrasound pathology. Fusion of ultrasound education into the sophomore medical school curricula provides students with unique learning opportunities in pathology.

#### **2385882 Effects of Ultrasound Training During Year 2 of Medical School on Year 3 Medical Students**

Reed Krause,\* Cassandra Krause, Raymond Krause, Vi Am Dinh

School of Medicine, Loma Linda University, Loma Linda, CA USA

**Objectives:** Medical students face many barriers to practicing point-of-care ultrasound (POCUS) during their year 3 clerkships. We hypothesized that hands-on ultrasound training during year 2 of medical school is an important factor in the preparation for using POCUS during year 3.

**Methods:** At our institution ultrasound training is formally integrated into the year 1 medical school curriculum but not the year 2 curriculum. Optional hands-on POCUS training events are offered throughout year 2. During year 3 orientation week, year 3 volunteers took the 22-point Ultrasound-Objective Structured Clinical Examination (US-OSCE) that they previously took on completion of year 1. It tested image acquisition and interpretation of the following systems: ocular, neck, pulmonary, cardiovascular, and abdomen. Following the US-OSCE, participants completed a survey to assess participants' comfort level with ultrasound.

**Results:** Of 68 participants, 78% (53/68) did not attend any POCUS training events during year 2, and 22% (15/68) did attend at least 1 training event. Comparing participants who did not attend versus participants who did, the mean US-OSCE score was 65.1% ± 20.0% versus

93.0%  $\pm$  10.2% ( $P < .01$ ). The mean completion time was  $559 \pm 81$  versus  $422 \pm 118$  seconds ( $P < .01$ ). The survey showed 34.0% versus 93.3% ( $P < .01$ ) of participants reported they were comfortable or very comfortable with the function of the US machine; 15.1% versus 73.3% ( $P < .01$ ) of participants reported they were comfortable or very comfortable with US use on patients.

**Conclusions:** Attending POCUS training events during year 2 of medical school increases year 3 medical students' overall comfort level with ultrasound and increases preparedness for using POCUS in year 3 clerkships.

### 2385893 Effectiveness of Animated Simulation for Teaching the Rapid Ultrasound for Shock and Hypotension Protocol to Medical Students

*Reed Krause,\* Michael Douglas, Drew Sheldon, Vi Am Dinh*  
School of Medicine, Loma Linda University, Loma Linda, CA USA

**Objectives:** Although the benefits of simulation training for resident physicians have been well established, its role in medical school ultrasound education is unclear. The goal of this study was to evaluate the effectiveness of teaching the rapid ultrasound for shock and hypotension (RUSH) protocol to medical students using combined didactics and animated simulation.

**Methods:** Enrolled subjects were medical students who voluntarily participated in the RUSH simulation module in an ultrasound symposium. This study is a self-controlled prospective observational cohort study, in which subjects' confidence in utilizing ultrasound for diagnosing shock was assessed before and after the training (comparisons analyzed with the Mann-Whitney  $U$  test). Student satisfaction and perceived training effectiveness were also evaluated.

**Results:** Of the participants, 25 completed both preliminary and postcourse surveys. Responses represent students from 6 different institutions consisting of both MD and DO programs: 88% and 12% respectively. Overall, students were "very satisfied" (median 9/10), and 56% "strongly agree" that combining didactics and simulation was effective for teaching RUSH. In the preliminary survey, participants were "not at all confident" in using ultrasound to diagnose shock, but the postcourse survey showed they had become "confident" following the course ( $P < .05$ ).

**Conclusions:** As evidenced by subjects' satisfaction, improved confidence, and overall impression of the course's effectiveness, we conclude that integrating combined didactic and animated simulation style lectures into a medical student ultrasound curriculum can be effective. Further studies are required in order to quantify the value of supplementing didactics with simulation when compared to didactics alone.

### 2386074 Ultrasound Immersion Week: An Innovative Approach to Instructing Medical Students in Ultrasound

*Manickam Kumaravel, Varun Rachakonda\**  
Radiology, University of Texas, Houston, TX USA

**Objectives:** The intentions of the ultrasound education program were to: (1) create an intensive ultrasound curriculum by designing a program, Ultrasound Immersion Week, aimed specifically at medical students; (2) devise a method for measuring effectiveness of the program; (3) assess the feasibility of teaching this methodology for various audiences in different institutions.

**Methods:** Analyze existing ultrasound education. Evaluate current status and gaps. Devise curriculum for 2nd-year medical students in ultrasound education at our institution, including instrumentation, anatomy, and ultrasound-guided interventional procedures using phantoms. Conduct pre- and post-Immersion Week assessments of skills and knowledge with a standardized questionnaire and hands-on competition. Program overview: (1) hands-on education of various systems using mul-

tiple ultrasound units and students divided into small groups; radiology resident educators to guide; (2) ultrasound-guided intervention using homemade phantoms; (3) ultrasound skills competition; (4) standardized questionnaire—pre- and post-week evaluations; (5) medical student and resident satisfaction surveys.

**Results:** Evaluation performed by: (1) standardized questionnaire administered to 245 students (Table 1); (2) satisfaction survey using surveymonkey.

**Conclusions:** (1) Short focused ultrasound education programs are useful and effective in educating medical students. (2) A standardized questionnaire demonstrates that it is possible to have a significant impact on the knowledge obtained by medical students by a week of ultrasound education. (3) Using homemade phantoms, it is possible to educate 2nd-year medical students effectively and keep them engaged. (4) It is possible to propagate this method of education to other centers using videos and pictures.

Table 1. Results of Pre- and Post-Immersion Knowledge Evaluation Questionnaire

	Pre-Immersion	Post-Immersion
Mean	2.87	3.82
SD	1.09	1.03
SEM	0.07	0.08
n	213	154
2-tailed $P$	<.0001	<.0001

### 2387786 Posttraumatic Arteriovenous Malformation of the Neck: B-Mode Sonographic, Color Doppler Sonographic, and Magnetic Resonance Imaging Findings

*Hasan Yerli*

*Baskent University, Izmir, Turkey*

**Objectives:** Imaging findings that are related to posttraumatic arteriovenous malformation (AVM) of the neck are little known in the literature. We present the findings of B-mode sonography, color Doppler sonography, and magnetic resonance imaging (MRI) of posttraumatic AVM localized in the neck region.

**Methods:** A 31-year-old woman was admitted to the Department of Radiology for evaluation of a mass in her right neck. After the physical examination, B-mode sonography, color Doppler sonography, and MRI were performed. After surgical excision, the diagnosis was confirmed by histopathology.

**Results:** The physical examination revealed a nontender mass. In her history, there was an enlarging and shrinking mass in the her right neck region. A heterogeneous solid soft tissue mass with regular contours located in the midjugular region having dimensions of  $4.5 \times 4.5$  cm was determined on B-mode sonography. The mass had central vascularity on the color Doppler examination. On the MRI examination, the mass with a central hemorrhagic component was heterogeneously isointense with the muscle on T1-weighted images. Postcontrast images showed peripheral enhancement of the mass and its feeding artery and drainage vein. It had a multilobulated contour and was heterogeneously hyperintense with the muscle on T2-weighted images. The histopathologic examination showed thin and thick-walled arterial channels with adjacent venous channels.

**Conclusions:** Posttraumatic AVM that appears as a rare condition should be kept in mind in patients having a trauma history for the differential diagnosis of neck masses. The presence of central vascularity on color Doppler sonography and determination of a hemorrhagic component, the feeding artery, and a drainage vein on MRI may be important findings supporting the diagnosis of AVM of the neck.

## Sonography: Practice Management

### 2385745 A Pictorial Display of Inflammatory Bowel Disease on Sonography: Its Diagnosis, Activity, and Complications *Christina Merrill<sup>1</sup>,\* Alexandra Medellin-Kowalewski<sup>2</sup>, Stephanie Wilson<sup>2,3</sup>*

<sup>1</sup>Diagnostic Imaging, Foothills Medical Center, Calgary, Alberta, Canada; <sup>2</sup>Radiology, <sup>3</sup>Medicine, Division of Gastroenterology, University of Calgary, Calgary, Alberta, Canada

**Objectives:** To demonstrate how sonographic evaluation of inflammatory bowel disease (IBD) can be an effective tool for the diagnosis, determination of disease activity, and identification of the most common complications of stricture, perforation, mechanical bowel obstruction, and fistula.

**Methods:** Sonographic evaluation of the bowel is performed according to a dedicated protocol with overlapping sequences of longitudinal and axial scans, to encompass the entire colon and small bowel. A survey is performed with a standard abdominal convex ultrasound probe. All abnormal bowel segments are interrogated with a higher-frequency convex or linear probe, 6–9 MHz, with a variable focus. Endovaginal and perianal scans are routine in the evaluation of deep pelvic and perianal disease, respectively. The location of the abnormal segments is recorded, as well as their length and thickness. Observations reflective of inflammation, including wall thickness, inflammatory fat, and signal on color Doppler, are graded from 0, suggesting normal or inactive disease; through 1, mild; 2, moderate; and 3, severe inflammatory activity. These provide an ultrasound global assessment. Complications are identified according to their familiar appearance on grayscale ultrasound with the benefit of real-time assessment with its high temporal resolution.

**Results:** Sonography provides high-resolution evaluation of any abnormal segment of bowel. The procedure has no ionizing radiation and is highly acceptable to patients. Disease presence at diagnosis or recurrence following surgery is shown on sonography with equivalence to computed tomography and magnetic resonance imaging. Sonography is valuable for establishing baseline activity prior to initiation of medical therapy and can be useful also in monitoring response. Dynamic real-time sonography shows a sensitive ability to detect and characterize common complications, including stricture and incomplete mechanical bowel obstruction.

**Conclusions:** Sonographic assessment of IBD is safe, cost-effective, and accurate. The method is highly acceptable to patients and should be considered for imaging evaluation of patients at the time of disease diagnosis, for monitoring surveillance, and at the time of acute exacerbation.

## Therapeutic Ultrasound

### 2385067 Maturation of Lesions Induced by Myocardial Cavitation-Enabled Therapy

*Xiaofang Lu,\* Douglas Miller, Chunyan Dou, Yiyang Zhu, Mario Fabilli, Gabe Owens, Oliver Kripfgans*  
University of Michigan, Ann Arbor, MI USA

**Objectives:** Lethal cardiomyocyte injury induced by a cavitation response of microbubbles to ultrasound pulses indicated a potential application for tissue reduction therapy, as for hypertrophic cardiomyopathy (HCM). The aim of this study was to observe and characterize the maturation of the lesions and the extent of tissue loss 6 weeks after cavitation-enabled therapy under 2 different ultrasound exposure parameter settings.

**Methods:** Dahl/SS rats were anesthetized and treated by high-amplitude pulsed ultrasound guided by 10-MHz ultrasound images. Contrast microbubbles were infused via a tail vein during intermittent pulse-burst exposure at 4 MPa peak rarefactional pressure amplitude. A sham group, a low-impact group (group A; 5 cycle pulses with Gaussian modulation and a 1:4 trigger for 5 minutes), and a high-impact group (group B; 10 cycle pulses with 4-millisecond square modulation and a 1:8 trigger for 10 minutes) were tested.

**Results:** Higher exposure used in group B yielded more substantial injury than lower exposure in group A. Higher premature ventricular complex percentages during exposure and higher blood troponin I levels 4 hours after exposure occurred for group B. No injury was found in shams. Treated rats in both groups A and B had significant increases in wall thickness measured by echocardiography the next day, which returned to normal by the end of 6 weeks. Maturation of lesions involved fibrosis replacement, preserving structural tissue integrity. Six weeks after ultrasound exposure, heart tissue samples in group B showed more evident fibrosis in Masson's trichrome-stained histology, with the microlesion fraction in the center of the damaged area ranging from 0.21 to 0.49.

**Conclusions:** This study showed that cavitation-induced myocardial injury progressed into permanent loss of myocardial tissue that was sufficient for possible HCM therapy. However, no actual reduction of heart wall thickness was measurable in the present study due to the fibrosis replacement. More research is needed to evaluate the functional impact of treatment, including possible pharmaceutical means to reduce the replacement scar volume, in order to define the treatment parameters required for symptomatic relief for HCM.



# Continuing Medical Education (CME) Credit Information

## 2016 AIUM Annual Convention

### Activity Description

The 2016 AIUM Annual Convention and Preconvention Program is the most comprehensive, cutting-edge meeting for the entire medical ultrasound community. Our unique multidisciplinary program provides a collaborative environment for all specialties and disciplines, from beginner to advanced.

### Accreditation Statement

The American Institute of Ultrasound in Medicine (AIUM) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide CME activities for physicians.

### Designation Statement for the 2016 Preconvention Program

The AIUM designates this live activity for a maximum of up to 7.5 *AMA PRA Category 1 Credits*<sup>™</sup>. Physicians should claim only the credits commensurate with the extent of their participation in the activity.

### Designation Statement for the 2016 Convention

The AIUM designates this live activity for a maximum of up to 29.0 *AMA PRA Category 1 Credits*<sup>™</sup>. Physicians should claim only the credits commensurate with the extent of their participation in the activity.

### Credits for Sonographers

Sonographers participating in AIUM educational activities may earn credits toward maintaining their professional certification from the following organizations:

#### American Registry for Diagnostic Medical Sonography (ARDMS)

The ARDMS accepts *AMA PRA Category 1 Credits*<sup>™</sup>.

#### American Registry of Radiologic Technologists (ARRT)

The AIUM is a Recognized Continuing Education Evaluation Mechanism (RCEEM) for the ARRT. These educational activities are approved by the AIUM for 7.5 ARRT Category A Credits for the 2016 AIUM Preconvention Program and 29.0 ARRT Category A credits for the 2016 Convention.

### Target Audience

This activity is designed to meet the needs of ultrasound professionals from various medical disciplines and specialty areas who perform and interpret ultrasound examinations.

### Course Objectives

On completion of this learning activity, participants should be able to:

- Demonstrate updated knowledge in basic science and instrumentation, cardiovascular ultrasound, contrast-enhanced ultrasound, dermatologic ultrasound, fetal echocardiography, general and abdominal ultrasound, gynecologic ultrasound, high-frequency clinical and preclinical imaging, interventional-intraoperative ultrasound, musculoskeletal ultrasound, neurosonology, obstetric ultrasound, pediatric ultrasound, point-of-care ultrasound, sonography, ultrasound in resource-limited areas, and therapeutic ultrasound.
- Discuss state-of-the art ultrasound research.
- Practice updated ultrasound skills for more effective diagnosis.
- Apply updated knowledge and clinical skills in improving patient care.

### Activity Designed to Change

Competence and performance.

### Accreditation Council for Graduate Medical Education (ACGME)

#### Competencies

These courses are designed to meet 1 or more of the following ACGME competencies: interpersonal and communication skills, medical knowledge, patient care and procedural skills, practice-based learning and improvement, professionalism, and systems-based learning.

### Disclosure Policy

As a provider accredited by the ACCME, the AIUM must ensure balance, independence, objectivity, and scientific rigor in its educational activities. Course directors, the planning committee, faculty, and all others who are in a position to control the content of this educational activity are required to disclose all relevant financial relationships with any commercial interest related to the subject matter of the educational activity. The AIUM may identify and resolve any conflicts of interest prior to the activity.

### Disclosures for This Activity

The faculty, committee members, community officers, AIUM leadership, and AIUM staff involved in planning this CME activity have completed a Disclosure of Financial Relationship. Individuals with disclosures are listed in this issue of the *Official Proceedings*. Disclosures are available for review on request.

### Documenting CME Credits

The AIUM provides CME certificates to those who have participated in an AIUM educational activity. The AIUM does not submit credits to regulating bodies or certifying organizations on behalf of the participant. It is the participant's responsibility to submit proof of credits on his or her own behalf.

### Disclaimer

The information presented in this activity represents the opinion of the faculty and is not necessarily the official position of the AIUM.

Committee members and AIUM staff involved in planning this CME activity have completed a *Disclosure of Financial Relationship*. All completed disclosure forms are on file and available for review at the AIUM office. Only individuals with disclosures are listed.

Lex, Amy  
Philips Healthcare: employee;  
salaried

Mastrobattista, Joan  
Counsyl: medical advisory board;  
no monetary remuneration

Nakamoto, Dean  
Galil Medical: investigator;  
research support

Toshiba America Medical Systems:  
no remuneration; research  
agreement

Needles, Andrew  
FujiFilm Visual Sonics, Inc:  
employee; salary

Noble, Vicki  
Sonosite, Inc: honorarium; speaker

Robbin, MichelleS  
Philips Healthcare: evaluate new  
equipment; UAB grant

Scoutt, Leslie  
Philips Healthcare: honoraria;  
speaker

Shwayder, James  
Cook Women's Health: co-inventor  
Goldstein Sonobiopsy Catheter;  
royalties

Solomon, Julia  
DePuy Synthes Orthopedics:  
spouse/partner; educational  
support; honorarium  
GE Healthcare: educational  
support; honorarium

Swanson, Terri  
PfizerInc: employee; salary, stock

Tomar, Anju  
GE Healthcare: employee; salary

Wells, Chet Edward  
UpToDate: author/consultant;  
consulting fee

## Faculty Disclosures

Below are faculty members who disclosed that they have relevant relationship(s) with commercial interest(s) that may create a conflict of interest. Faculty members are instructed to advise the AIUM if new financial relationships with commercial interests arise since completing their disclosure forms. Described below each name are the commercial interest(s) and the nature of the financial relationship(s). Disclosures, if any, are listed under the speaker's name. Only individuals with disclosures are listed. All completed disclosure forms are on file and available for review at the AIUM office.

Abramowicz, Jacques Philips Healthcare: research machine	Halmann, Nahi GE Healthcare: Salary	Platt, Lawrence Ilumina: Honorarium GE Medical System: Honorarium Research Support
Barr, Richard Analogic Ultrasound: researcher; research grant Philips Ultrasound: equipment grant; lecturer; lecture fees; researcher Siemens Ultrasound: equipment grant; lecturer; lecture fees; researcher Supersonic Imagine: equipment grant; lecturer; lecture fees; researcher	Henwood, Patricia FujiFilm SonoSite: Travel Expenses	Raio, Christopher Zonare Medical Systems: Consulting Fee
Brown, III, William Philips Ultrasound: Fees	Huang, Dean Bracco: Honorarium	Rapp, Cindy Employee Toshiba America Medical Systems: Salary
Chrisman, Meredith Visualsonics: Yearly Salary Toshiba: Yearly Salary	Kripfgans, Oliver Equipment support: Ultrasound scanner and probes from GE Equipment support: Ultrasound probe from Zonare	Robbin, Michelle Philips Medical: Research Grant
Coley, Brian Elsevier: Royalties	Lex, Amy Philips Ultrasound: Salary	Ryan, Sarah Biogen, Inc: Salary
D'Agostini, Deborah GE Healthcare: Salary	Medford, William SonoSite, Inc: Salary	Scoutt, Leslie Philips Healthcare: Honoraria
DeVore, Gregory GE Healthcare: Consultant	Moore, Christopher Philips Healthcare: Consultant fee	Sidhu, Paul Bracco SpA: Honorarium Lecture fees Siemens AG: Honorarium Lecture fees
Dighe, Manjiri General Electric: Grant support	Nakamoto, Dean Toshiba America Medical Systems: Research Agreement, No remuneration	Solomon, Julia GE Healthcare: Honorarium for preparation of educational materials
Dighe, Manjiri General Electric Healthcare: Research funding	Napolitano, David Zonare Medical Systems: Salary	Swanson, Terri Pfizer Inc: Salary, Stock
Eichten, Alexandra Regeneron Pharmaceuticals: Salary	Needles, Andrew FUJIFILM VisualSonics: Employment	Tanter, Mickael Supersonic Imagine: Co-founder and ShareHolder
Eisenbrey, John GE Healthcare: Research Support	Nelson, Bret EyeLife: Stock	Wiskin, James QT ultrasound LLC: Salary and Stock Interest
Filice, Carlo Philips Healthcare: Speaker fee	Nightingale, Kathryn Siemens: Research agreement exchanging technical support/access for nonexclusive rights to IP	
Forsberg, Flemming GE: Honorarium	Norton, Mary Natera: Unrestricted research grant to my institution on my behalf	
Goncalves, Luis Philips Healthcare:	O'Hara, Sara Toshiba Medical Ultrasound: Honoraria	



## Disclosure of Commercial Support for the 2016 AIUM Annual Convention

### ADVERTISING

CIVCO Medical Solutions  
Clarius Mobile Health  
Nanosonics, Inc.  
Samsung  
Siemens Medical Solutions USA, Inc.  
SonoSite

### DURABLE EQUIPMENT DONATIONS

BK Ultrasound  
Esaote  
Gammex  
GE Healthcare  
Hitachi Aloka Medical  
Konica Minolta Medical Imaging  
Parker Laboratories, Inc  
Philips Healthcare  
Samsung  
Siemens Medical Solutions USA, Inc.  
SonoSite  
SuperSonic Imagine  
Terason  
Toshiba America Medical Systems, Inc.

### SUPPORT

Clarius Mobile Health  
Carestream Health  
GE Healthcare  
HR Pharmaceutical, Inc.  
Parker Laboratories  
Samsung

# Index

## A

Abdel-Latif A 108  
 Abe T 74  
 AboEllail M 38, 52, 61  
 Abramowicz J 115  
 Abu-Rustum R 40, 46, 62, 63, 91, 115  
 Abu-Rustum S 62, 63  
 Abuhamad A 8, 52, 96  
 Adalsteinsson E 100  
 Adams N 52  
 Aderek G 73  
 Adeyiga A 106, 117  
 Adhikari S 13  
 Adzick NS 8  
 Ahmad S 77, 80, 82  
 Ajzen S 51  
 Akhtar S 84  
 Alazraki A 44  
 Albadawi N 80  
 Alcázar JL 97  
 Alerhand S 116  
 Alexander M 37  
 Alfageme F 34  
 Alizad A 36  
 Allen A 17  
 Allen C 118  
 Alsup C 42  
 Amini R 13  
 Aminololama-Shakeri S 101  
 Amorosa J 110  
 Amponsah D 120  
 Anaya H 115  
 Anderson C 43, 87  
 Anderson N 18  
 Andrus P 11  
 Araki T 5, 25  
 Archer T 56  
 Arevalo S 10, 11  
 Armstrong LA 109  
 Ash A 77, 78, 82  
 Ashwal E 19  
 Assaf S 79  
 Atan I 53, 54  
 Au A 42  
 Augenstein J 81  
 Avery T 28  
 Avitan T 111, 113  
 Avner J 58  
 Ayers C 97  
 Ayoub J 72

## B

Bachman K 120  
 Baer G 18  
 Bahner D 45, 70, 75, 76, 85, 88, 89, 90, 118, 120  
 Bahtiyar M 62  
 Bailey M 23

Bajaj K 41  
 Bajaj T 78, 82  
 Balestrieri A 5  
 Balica A 97, 98  
 Balk A 83, 86  
 Balteanu B 24  
 Banchhor S 5, 25  
 Bandarkar A 106, 117  
 Bandong I 102  
 Bangerter K 96  
 Banks A 71  
 Bard R 101  
 Bardin R 19  
 Barker M 101  
 Barr R 15  
 BassGoldman T 15  
 Battaglia P 106  
 Bayat M 36  
 Bebbington M 38  
 Becker B 76  
 Belfort M 9, 10, 11  
 Belmont B 84  
 Ben-Shlush A 57  
 Benion N 7  
 Bennett T-A 36, 39, 114, 116  
 Benson C 58  
 Berger A 28  
 Bergh E 110  
 Berkenblit R 92, 95  
 Berkowitz R 78, 80, 82  
 Bernaba M 94, 113, 119  
 Bernstein S 65  
 Berry G 42  
 Betteridge B 18  
 Bhan A 15, 48  
 Bhat S 68  
 Bhoil R 34  
 Bi X 48  
 Bianco A 110  
 Bibbo C 100  
 Bigelow J 3  
 Bishop M 15  
 Bober J 75  
 Bockbrader M 70, 120  
 Boozarjomehri F 19, 20  
 Boughton J 94  
 Boulger C 76, 85, 88, 89, 90  
 Bouzghar G 91  
 Boyd J 84  
 Brain U 113  
 Braun M 10  
 Braverman M 54  
 Breed W 80  
 Britto I 9  
 Bromley B 9  
 Brown A 50  
 Brownlum M 113  
 Bruce M 50  
 Bruckner T 30  
 Bryant L 99

Buchanan K 77  
 Buck A 50  
 Budhram G 74  
 Budimlic S 68  
 Buisman W 33  
 Bullen J 17  
 Burnett-Roy S 45  
 Butler M 32  
 Byars D 43, 45, 46, 47, 87, 88

## C

Cabeza R 34  
 Callstrom M 48  
 Canavan T 65  
 Cano A 98  
 Cantonwine D 41, 65  
 Carmona S 81  
 Carreras E 10, 11  
 Cary T 91  
 Casey B 64  
 Cass D 9  
 Caughey M 26  
 Cavanaugh B 27, 91  
 Cerezo E 34  
 Chan K 86  
 Chandra S 42  
 Chang C 89, 90  
 Chang T-H 27  
 Chao J 75, 80  
 Charboneau N 68  
 Chauhan A 33, 49  
 Chen C 95  
 Chen F 28  
 Chen L 15  
 Chen S 48, 69  
 Chen T 27  
 Chen Z 15  
 Cheng R-f 96  
 Cheng W 60  
 Cheng X 38  
 Cheng Y 6  
 Chervenak J 116  
 Chhaganlal K 78  
 Ching B 105  
 Chiricolo G 83, 86  
 Cholvi S 98  
 Christiansen M 53  
 Chung R 48  
 Chyan R 13, 44  
 Cipi A 87  
 Clark E 114  
 Coad B 112  
 Cohen HL 58  
 Cohen I 7  
 Cohen L 62  
 Cohen S 44  
 Cohen W 115  
 Coiado O 22  
 Colcord C 83

Connolly K 87, 110  
 Connor V 96  
 Copel J 62  
 Copeland J 109  
 Coquia S 31  
 Corrado M 89, 90  
 Cosgrove D 15, 72  
 Coyle P 17  
 Cramer K 78  
 Crino J 38  
 Cronsell J 74  
 Cross K 11  
 Cruze L 110  
 Cunitz B 23  
 Cunningham T 52  
 Cupp J 76  
 Cuxart A 10, 11  
 Czaplicki C 32  
 Czernuszewicz T 26

## D

Dahiya N 31, 32, 92  
 Daley J 90  
 Damrell X 89  
 Dang E 69  
 Daniels J 105  
 Danko J 99  
 Daou L 63, 91  
 Dar P 109  
 Daswani D 58  
 Dave J 7, 27, 55  
 David L 112  
 Davis T 94, 113, 119  
 Davis-Nelson S 111  
 De Jong MR 4, 31  
 de la Vega A 41  
 de Souza L 6  
 Delaney M 82  
 Delzell P 17  
 DeMarco A 15  
 DeMarco P 15  
 Dempsey R 49  
 Denis M 36  
 Denney J 109  
 Desai K 42  
 Dessert T 92, 93, 94  
 Destounis S 26  
 Detti L 53  
 DeVore G 40, 63, 64  
 Dezelon L 81  
 Dhyani M 15, 48, 50  
 Dickman E 116  
 Dietrich C 72  
 Dietz H 53, 54  
 Dighe M 23  
 Dilcher B 117  
 DiMuzio P 6  
 Dinh VA 13, 44, 114, 119, 120, 121

Dobruch-Sobczak K 4  
 Dobson L 9  
 Docherty M 45  
 Dokus K 99  
 Dolin C 36, 39, 114, 116  
 Donepudi R 38  
 Dong G 21  
 Dong H 6  
 Dong Y 33, 60  
 Donlon K 70  
 Dou C 68, 122  
 Doubilet P 58  
 Douglas M 119, 121  
 Downey J 100  
 Drelich-Zbroja A 31  
 Dryden M 119  
 Dschaak T 45, 76, 85, 88, 89  
 Du L-J 15  
 Duanmu Y 84  
 Duda K 73  
 Dulani T 83, 86  
 Dumon K 49  
 Dungan J 7, 62, 107  
 Dumire B 23  
 Duryea E 64  
 Dyball J 118  
 Dziadosz M 19, 20, 36, 39, 114, 116

## E

Easter S 41  
 Edington S 8  
 Egan S 97, 98  
 Ehsanipoor R 110  
 Eisenbrey J 27, 28, 29, 37, 55, 59, 91, 99  
 Elezi E 116  
 Ellspermann R 82  
 Elzie C 118  
 Espinoza J 10  
 Evans D 14, 43  
 Ewald I 32

## F

Fabiilli M 122  
 Fakhry C 31  
 Fanous M 70  
 Farber J 6  
 Farber M 26  
 Farhat R 112  
 Fatemi M 36  
 Fazio R 36  
 Feldstein V 32, 100  
 Feleppa E 35  
 Fernandez-Sanguino A 97  
 Ferraioli G 50  
 Ferre R 84  
 Fidelman N 32  
 Fields J 42  
 Finch L 112  
 Finley L 18  
 Finnoff J 18  
 Fischer C 30  
 Fischman D 7

Fleenor J 8  
 Fleischer A 51  
 Fogg L 115  
 Fomenko V 69  
 Foran K 45  
 Ford P 26  
 Forsberg A 27  
 Forsberg F 6, 7, 27, 28, 29, 37, 55, 60, 71, 91, 99  
 Fowlkes JB 40  
 Fox JC 43, 69, 78, 79, 80, 87, 94, 113, 119  
 Fox K 10, 11  
 Fox T 27, 29  
 Francescon D 45  
 Frank S 92, 95, 118  
 Frates M 31, 58  
 French A 57  
 Friedman T 54  
 Friez K 79  
 Fryman C 77  
 Fu J 114  
 Fujita H 105  
 Fukuoka D 105  
 Fulton J 26  
 Fung C 84  
 Fusco D 15

## G

Gagoski B 100  
 Gallippi C 26  
 Gandhi R 10, 11, 54  
 Ganesan G 34  
 Gao J 15  
 Gao K 27  
 Gao M 108  
 Gao S 21  
 Gao W 28  
 Garbani N 70  
 Garcia M 20  
 Gardiner H 38  
 Garg A 17  
 Garg D 65  
 Gargollo P 10  
 Gaspari R 13  
 Gembicki M 7, 64  
 Ghooray K 94, 113, 119  
 Gianakon J 42  
 Gibson T 107  
 Gimovsky A 39, 61  
 Glanc P 34  
 Glass T 50  
 Gleason A 88  
 Goertz J 84  
 Gold D 75  
 Goldstein J 96  
 Gollin Y 111  
 Gomella L 60  
 Gomez L 66  
 Gondra-Sanabria S 13, 44  
 Gonzales M 76  
 Goodman R 57  
 Goodman Z 89, 90  
 Goodmurphy C 45, 46, 47, 118  
 Goodrich L 32

Gordon R 79, 81, 86  
 Gotteiner N 62, 107  
 Gottlieb J 32  
 Grajo J 48  
 Grant E 100  
 Graupera B 97, 98  
 Greenberger S 85  
 Greenleaf J 48  
 Gregory A 36  
 Grobman W 62  
 Gross D 56  
 Grotberg J 90  
 Gueng K 95  
 Guerriero S 97  
 Guidoni R 113  
 Gunther M 94, 113, 119  
 Guo M 21  
 Gupta I 55  
 Gupta N 11  
 Gupta R 50  
 Gupta S 71, 89, 90  
 Gustas C 102  
 Gutman D 118  
 Gwin J 41  
 Gylys M 94, 113, 119

## H

Haberman S 65  
 Habibollahi P 33  
 Hagbom R 44  
 Haines L 116  
 Haldeman-Englert C 109  
 Hall J 53  
 Halldorsdottir V 27  
 Halpern E 28, 60  
 Hamper U 31  
 Han A 35  
 Hanaoka U 61  
 Hangiandreou N 6, 68, 69  
 Hanson K 27  
 Haratz N 108  
 Haritos D 75  
 Harper J 23  
 Harper L 8  
 Harris A 92  
 Hart E 114  
 Hartge D 7, 64  
 Hata T 38, 52, 61  
 Hatch A 89  
 Hatz H 6  
 Hazard C 55  
 He W 15  
 He Y 74  
 Heller H 31  
 Heller M 84  
 Helou N 40  
 Henderson J 110  
 Henningsen C 45  
 Hentel K 15  
 Hereter L 97, 98  
 Hermann B 49  
 Hernandez C 115  
 Hernandez N 13  
 Hicks G 17  
 Hirsch L 19

Hines K 88  
 Hinshaw J 37  
 Hirachan T 65  
 Hoang Q 56  
 Hoffman M 39  
 Holland M 114  
 Holman M 31  
 Homeister J 26  
 Honart A 36, 39, 114  
 Hoppmann R 76  
 Horii S 8  
 Hosho K 94  
 Hosking A-M 32  
 Hough O 22  
 Howley L 83  
 Hsu E 28  
 Hsu H-H 27  
 Hu K 11  
 Huang L 27  
 Huang R 84  
 Huang S 58  
 Hug A 30  
 Hughes A 23  
 Hunt P 76  
 Hussien A 69, 85  
 Hutcheon J 111  
 Hutchinson D 34  
 Hutton K 108  
 Hynnen K 22, 23

## I

Ikeda D 100  
 Ikeda N 5, 25  
 Illescas T 10, 11  
 Ingle A 16, 37  
 Ishibashi M 38  
 Isomoto H 71, 94  
 Ito H 105  
 Ito M 61  
 Iyooob S 8

## J

Jackson B 30, 59  
 Jackson D 49  
 Jacobson J 57  
 Jang H-J 72  
 Jannach L 83  
 Jargiello T 31  
 Jeffrey RB 92, 93, 94  
 Jenkins S 8  
 Jeong D 105  
 Jeremic A 23, 24  
 Ji Z-B 33  
 Jiang Y 55  
 Jin C 74  
 Johnson A 11, 38  
 Johnson C 110  
 Johnson T 11  
 Jones B 34  
 Jones M 43, 87  
 Jones R 81  
 Joshi A 62, 96  
 Joyce M 14, 43K  
 Kaban N 84



Kamaya A 92, 93, 94  
 Kanenishi K 52  
 Kaplan S 94, 113, 119  
 Karakash S 65  
 Karshen R 6, 48  
 Katagiri K 73  
 Katz J 25  
 Katzman P 39  
 Kaur N 75, 108  
 Kayagil T 43, 87  
 Kelleher M 12  
 Kelly N 89, 90  
 Kelly R 108  
 Kendall M 94, 119  
 Kennedy M 76, 85  
 Kerlan R 32  
 Kerr L 51  
 Kessler R 84  
 Ketterling J 56  
 Kettner N 106  
 Khalek N 8  
 Khandelwal S 85  
 Khorochkov E 72  
 Kiger J 110  
 Kim C-S 98  
 Kim J 18  
 Kim SY 35  
 Kim TK 72  
 King A 85  
 King Ja 42  
 King Jo 42  
 King O 83  
 Kittisarapong N 77, 82  
 Kleinman G 106, 107  
 Kline J 75  
 Kluger S 116  
 Knapp B 45, 46, 47, 87, 88  
 Kneitel A 40  
 Knight J 36  
 Knight RS 105  
 Kobi M 93  
 Koda M 71, 94  
 Koenigsberg M 92, 95  
 Koenigsberg T 118  
 Koh C 10  
 Kohi M 32  
 Kohut A 71  
 Kolli K 32  
 Kolokythas O 50  
 Kono Y 72, 92  
 Korte J 110  
 Koski C 6  
 Kotha J 88  
 Kowalski T 29  
 Krammer D 30  
 Krause C 119  
 Krause K 120  
 Krause R 114, 119, 120, 121  
 Krebs M 88  
 Kriegshauser JS 32  
 Kripfgans 68  
 Kripfgans O 40, 122  
 Krix M 30  
 ksamietiene E 99  
 Kuca P 73

Kudela E 99  
 Kulkarni S 7  
 Kulwin J 94, 113, 119  
 Kumar K 5  
 Kumar V 3  
 Kumaravel M 121  
 Kurdi H 17  
 Kurian J 58  
 Kuroda H 74

## L

Laberge J 32  
 Lahham S 43, 78, 80, 87  
 Lai X 55  
 Laijfer S 107  
 Laijfer-Narin S 57  
 Laird J 5, 25  
 Lallas C 59  
 Landau D 108  
 Lane D 119  
 Langer J 93  
 Langer S 53  
 Lara O 97  
 Larson K 52, 96  
 Lasure B 117  
 Latifi S 81  
 Lattanzio F 45, 46, 47  
 Laucekova Z 99  
 Lavra F 5  
 Lawson E 119  
 Leavitt K 41  
 Lebovitz D 81  
 Lee C 84  
 Lee F 23  
 Lee F jr 37  
 Lee K 18  
 Lee S 35, 36, 39, 72, 114  
 Lee S-K 95  
 Lee S-U 105  
 Lee W 9, 10, 11, 35, 54, 64  
 Lee Y 6  
 Lehrman E 32  
 Leitão Y 99  
 Leo M 41  
 Levine M 116  
 Lewin P 21  
 Lewis M 83  
 Li C 15, 48  
 Li H 55  
 Li M 21  
 Li Q 50  
 Li S 15  
 Lim K 113  
 Lin M 78, 83, 86  
 Lin Y 27  
 Lipson J 100  
 Litniewski J 4  
 Little S 9  
 Liu G 29, 60  
 Liu J 14  
 Liu J-B 27, 29, 55, 59, 99  
 Liu R 12, 43  
 Liu Y 68  
 Liu Z 21, 22, 28  
 Lloveras A 98

Lo D 13, 44  
 Lockhart M 30, 59  
 Loeffler P 86  
 Lombardi M 7  
 Londhe N 5, 25  
 Long Z 6, 69  
 Loren D 29  
 Lu M 29  
 Lu X 68, 122  
 Lubner M 37  
 Ludeman L 80  
 Luo 100  
 Lyon M 79, 81, 86  
 Lyshchik A 28, 29, 55, 59, 72

## M

Macedo T 6  
 Machado P 6, 27, 91  
 Machi J 35  
 Mack L 10, 11, 35, 54  
 Madden J 50  
 Magpoc J 53  
 Mahboob S 95, 112  
 Maher J 108  
 Mahmoud G 91  
 Majdanska M 73  
 Majmudar A 58  
 Maksoud C 99  
 Malek G 73  
 Maliborski A 73  
 Malik Z 44  
 Mallafre A 97  
 Mamou J 35, 56  
 Manaktala R 14  
 Manduca A 48  
 Mangan J 78  
 Manjiri D 50  
 Mann L 38  
 Manning W 70  
 Manwani D 58  
 Mao F 33, 60  
 Mari G 66  
 Marin J 75  
 Maroto A 10, 11  
 Marshall A 27  
 Marshall J 109  
 Marston W 26  
 Martins J 54, 113  
 Mashima M 38, 52  
 Mastrobattista J 10, 11  
 Matang S 91  
 Matono T 71, 94  
 Matsuo M-C 32  
 Matsuo T 105  
 Matthews K 110  
 Mattox R 106  
 Maturen K 92  
 Mayer C 111  
 Mazza R 110  
 Mazzariol F 92, 95  
 McAleavey S 39  
 McCole S 118  
 McCormick A 115  
 McCracken C 44  
 McDermott R 120

McDonald M 7  
 McGann S 116  
 McGuine T 18  
 McIntire D 64, 66  
 McKinney D 20, 21  
 Medellin-Kowalewski A 122  
 Meek R 107  
 Mefford J 78  
 Mehendale R 115  
 Mehrmohammadi M 36  
 Mehrotra P 7  
 Meixner D 36, 48  
 Meizner I 19  
 Mellem D 48  
 Mendoza C 83, 86  
 Mercer J 72  
 Merino F 11  
 Merrill C 122  
 Meshram N 49  
 Meyers L 109  
 Mikkilineni M 85  
 Milkowski A 49  
 Miller C 29  
 Miller D 68, 122  
 Miller J 25, 94, 113, 119  
 Miller M 110  
 Miller R 39, 57  
 Miller Z 50  
 Minardi J 17, 117  
 Mitchell B 69  
 Mitchell C 49  
 Miyoshi K 71, 94  
 Modayil V 82  
 Mohanty M 71  
 Moise K 38  
 Momin A 31  
 Momin S 31  
 Monteagudo A 18, 116  
 Moon-Grady A 61  
 Moore C 12  
 Moore CL 43, 90  
 Moore L 118  
 Morales I 79  
 Morales Y 38  
 Mordechay D 57  
 Morgan J 66  
 Morgan T 92, 100  
 Mori N 61  
 Morris C 44  
 Morrow D 76  
 Moses M 92, 95  
 Murakami H 105  
 Murphy D 57

## N

Naftolin F 19, 20  
 Nagar A 75, 101, 108  
 Nagdev A 41  
 Nassar M 115  
 Nassr A 10  
 Needleman L 6  
 Nelson D 66  
 Nelson M 78, 82  
 Nepomuceno H 69  
 Newman R 110

Neylan C 49  
 Nichols T 26  
 Nicolaides A 5, 25  
 Niechayev M 69  
 Nightingale K 25, 50  
 Niku A 90  
 Nitta E 52  
 Norton J 11  
 Nowicki A 4

**O**  
 O'Brien W Jr 22, 35  
 O'Kane P 29, 37  
 O'Reilly M 22  
 O'Sullivan R 106, 107  
 Oberfoell S 57  
 Oberlander T 113  
 Odashima K 116  
 Odibo A 20  
 Oh K 107  
 Oh L 11  
 Oikawa S 73  
 Ojili V 75, 101, 108  
 Okamoto T 71, 94  
 Okano J 94  
 Oliver E 8  
 Olszewski R 4  
 Olutoye O 9  
 Onda S 107  
 Orejuela F 54  
 Ormachea J 39  
 Otten J 6  
 Owen J 8  
 Owens G 122

**P**  
 Pacardo R 102  
 Palanisamy A 100  
 Palatnik A 7, 62, 107  
 Palmeri M 50  
 Panchal A 89  
 Pangaonkar P 7  
 Papanna R 38  
 Pare J 12, 43  
 Pariseau G 112  
 Park H 93, 94  
 Parker K 3, 25, 39, 69  
 Paroder V 93  
 Parrott J 112, 114  
 Parvey L 58  
 Pascoe J 68  
 Pascual C 98  
 Pascual MA 97, 98  
 Patel A 89, 97  
 Patel M 32  
 Patel S 107  
 Patil A 18  
 Pellikka P 48  
 Peltier M 19, 20  
 Peters H 58  
 Phillips C 70  
 Pinheiro D 113  
 Pinter S 40

Piotrkowska-Wroblewska H 4  
 Piscaglia F 72  
 Pivo S 36, 39, 114  
 Plett S 32  
 Poder L 100  
 Polanco B 63, 64  
 Polascik T 50  
 Poshtmashad A 42  
 Pourmand A 42  
 Prakash S 92  
 Prats M 76, 85, 88, 89, 118  
 Pratt W 18  
 Pribitkin E 99  
 Puranik K 55  
 Pusateri A 85

**Q**  
 Qiao X 22

**R**  
 Rabiner J 58  
 Rachakonda V 121  
 Radeva P 5  
 Radulescu V 80  
 Raga F 98  
 Raio C 77, 78, 82  
 Rajaii R 69  
 Rajan J 5  
 Rajasekaran S 18  
 Ram S 101  
 Ramamoorthy EN 105  
 Ramin S 54  
 Rathod K 97  
 Raviv-Zilka L 57  
 Rebitski R 104  
 Reed K 115  
 Reeves G 71  
 Reiff E 9  
 Reinstein D 56  
 Rendon D 10  
 Ricci Z 95  
 Richards D 57  
 Richman D 58  
 Ritchie E 101  
 Robbin M 30, 59  
 Roberts J 92, 95  
 Robinson J 65, 100  
 Robinson K 32  
 Roche M 115  
 Rock A 107  
 Rocque B 49  
 Rodo C 10, 11  
 Rodriguez I 97, 98  
 Roman A 36, 39, 114  
 Romanova A 7  
 Rosas H 17  
 Rose G 11, 78, 80, 82  
 Rosen M 43  
 Rosenzweig S 50  
 Roth D 10  
 Rouse C 41  
 Roustan G 34  
 Ruano R 9, 10, 11

Rubert N 37  
 Rubin J 15, 40  
 Ruggiero N 7  
 Runyon M 11  
 Rupp J 84  
 Rurak D 113

**S**  
 Saba L 5, 25  
 Sadow C 31  
 Saegusa-Beecroft E 35  
 Safdar B 43  
 Said K 113  
 Saito M 113  
 Saitoh D 73  
 Sajapala S 61  
 Sakhel K 46  
 Salame N 32  
 Salguero I 34  
 Salimian M 42  
 Saller D 65  
 Samimi K 3, 26  
 Samir A 15, 48, 50  
 Sampathkumar A 35  
 Sananes N 9  
 Sanchez W 48  
 Sanders J 117  
 Sangi-Haghpeykar H 10, 35  
 Sanseverino A 13  
 Satou G 63, 64  
 Saul T 78, 80, 82  
 Savage M 7  
 Sayeed Y 17  
 Sayegh S 112  
 Schmalbach P 80  
 Schmidmaier G 30  
 Schneider P 7  
 Schroeder M 74  
 Schubert F 18, 36  
 Schultz S 91, 93  
 Scott L 52, 96  
 Scoville N 85  
 Secomski W 4  
 See F 116  
 Sehgal C 33, 34, 49, 91, 93  
 Seishima M 105  
 Self W 84  
 Settle B 109  
 Shafique S 5, 25  
 Shah V 58  
 Shahkolahi M 42  
 Shalaby-Rana E 117  
 Shamshirsaz A 10  
 Sharma A 5  
 Sharma I 46  
 Sharma YO 34  
 Shaw C 59  
 Sheedy S 48  
 Shek K 53  
 Sheldon D 121  
 Sheng J 18, 36  
 Sherban T 12  
 Shiga K 73  
 Shigueoka D 51

Shih A 84  
 Shih G 15  
 Shin D 80  
 Shin J 27  
 Shin K-S 117  
 Shin S 105  
 Shipp T 41  
 Shlossman P 39  
 Shokoohi H 42  
 Shraim R 37  
 Shrivastava V 25  
 Shuck Z 87  
 Shukla D 5, 25  
 Shwe S 79  
 Si Q 29  
 Siadecki S 78, 80, 82  
 Siddiqui A 29  
 Silva C 51  
 Silva D 113  
 Silverman R 56  
 Sima A 14  
 Simhadri P 98  
 Simmons D 102  
 Simpson L 57  
 Singh H 86  
 Singh T 24  
 Singhal S 76, 85, 88, 89  
 Sinkey R 20  
 Sinkovskaya E 8  
 Sintim-Damoa A 109  
 Sions JM 17  
 Sirlin C 72, 92  
 Sirsi S 59  
 Sjogren A 41  
 Skaugset M 75  
 Sklansky M 63, 64  
 Smith B 119  
 Smith K 56  
 Smith N 41, 65  
 Snowise S 38  
 Snyder K 107  
 Sohaey R 107  
 Sojka M 31  
 Song P 48  
 Sorensen M 23  
 Soudack M 57  
 Souweidane M 108  
 Spangler J 14  
 Spann S 80  
 Sridharan A 28, 55, 71  
 Stahlman B 76  
 Stanczak M 6, 7, 27, 28, 29, 55, 59, 71, 91, 99  
 Stankard B 82  
 Stanley C 109  
 Stanley R 75  
 Stein M 92, 93, 95  
 Stekel S 68, 69  
 Stewart V 52  
 Stocker G 112  
 Stodgell C 39  
 Stovall D 52  
 Strissel N 6, 68  
 Suarez I 23, 24  
 Suarez L 34

Subeh M 43, 78, 79, 80, 87  
 Subhas N 17  
 Subramaniam S 75  
 Sugihara T 71, 94  
 Sultan L 33, 91, 93  
 Sumnicht A 13, 44  
 Sun M 92  
 Sunderwirth R 78  
 Suri J 5, 25  
 Surya M 34  
 Suskin B 109  
 Szczërbo-Trojanowska M 31  
 Szyller A 97

## T

Tabbut M 12, 44, 81  
 Tabsh K 40  
 Taggart K 18  
 Takacs P 52, 96  
 Talamayan-Pascua R 32  
 Talbott N 102, 103, 104  
 Tanaka H 38  
 Tanaka T 52  
 Tang X 6  
 Tay E 116, 117  
 Tayal V 83  
 Taylor A 32  
 Taylor N 69  
 Taylor R 12  
 Teigen N 109  
 Teismann N 105  
 Templin M 11  
 Tenenbaum-Gavish K 19  
 Tenkumo C 61  
 Terabayashi N 105  
 Tessaro M 116  
 Thacker G 11  
 Thein S 69  
 Theyyunni N 84  
 Thiam A 10  
 Thiel J 23  
 Thomas J 102  
 Thomas S 12  
 Tiba M 84  
 Timor-Tritsch I 19, 20, 116  
 Tipton C 89, 90  
 Tjelta J 68  
 Tobiasz A 66  
 Tomkowski W 73  
 Toreno F 45, 46, 47  
 Torrico D 51  
 Tozer J 14, 43  
 Trabulsi E 28, 59, 60  
 Trace A 118  
 Tradup D 6, 68, 69  
 Trawinski Z 4  
 Treadwell M 40  
 Trent S 57  
 Trinsey L 71  
 Truong L 100  
 Tsai B 4  
 Tsai M 116  
 Tudela F 110  
 Turel F 54  
 Turer R 84

Turk E 100  
 Turner E 30, 43, 59  
 Twickler D 64

## U

Udrea D 13, 44  
 Unal E 110  
 Urban M 48  
 Urs R 56

## V

Valenzuela D 32  
 Valero B 98  
 Vallabh J 70  
 Vallabhaneni R 26  
 Valldecabres C 98  
 Vangel M 100  
 VanWhy C 7  
 Varghese T 3, 16, 26, 37, 49  
 Velasco A 32  
 Velasco T 17  
 Velcani A 77  
 Veluswamy H 109  
 Verma U 54  
 Victoria T 8  
 Vieira L 110  
 Villarama J 68  
 Villarreal L 13, 44  
 Vintzileos A 19, 20  
 Visnovsky J 99  
 Vitto M 14, 43  
 Vleugels M 96

## W

Wachsberg R 51  
 Walinsky P 7  
 Walker B 31  
 Wallace K 55  
 Wang F 28  
 Wang H 74  
 Wang J 6  
 Wang P 55  
 Wang W-P 33, 60  
 Wang X 49, 55  
 Wang Y 6  
 Wapnir I 100  
 Ward J 91  
 Ward K 84  
 Warshak C 20, 21  
 Wasnik A 92  
 Watanabe T 105  
 Way D 45, 88, 89  
 Wear K 3, 68  
 Webb M 16  
 Weber M-A 30  
 Weekes A 11  
 Weichert J 7, 64  
 Weiner C 112  
 Weiner S 61  
 Wells C 66  
 Wells S 37  
 Welty S 10  
 Wergin K 37

Werntz C 17  
 West J 30, 59  
 Wheatley M 37  
 Whitehead W 10, 11  
 Whitman G 26, 119  
 Wilbrand S 49  
 Wilkins-Haug L 9  
 Williams N 49  
 Willmann J 72  
 Wilson J 18  
 Wilson S 43, 72, 78, 79, 80, 87, 122  
 Wilson T 88  
 Winchester B 106  
 Witt D 102, 103, 104  
 Wiznitzer A 19  
 Wohlmuth C 38  
 Wolery J 68  
 Wong C 101  
 Wood D 61  
 Wood R 39  
 Wood SL 8  
 Woodbury G 18  
 Woodhouse L 32  
 Woodrow N 34  
 Wyman M 13

## X

Xie F 21  
 Xiong H 91, 93  
 Xiong X 22

## Y

Yabumoto T 105  
 Yamamoto K 38, 52, 61  
 Yan P 22  
 Yang W 37  
 Yang X 55  
 Yerli H 16, 121  
 Yogev Y 19  
 Yoshida H 81  
 You S 117  
 Young S 32  
 Youssefian A 43

## Z

Zafar H 93  
 Zafman K 110  
 Zagzebski J 37  
 Zakaria J 69  
 Zarzour J 30, 59  
 Zderic V 23, 24  
 Zehtabchi S 75  
 Zeifang F 30  
 Zeng W 40  
 Zhang B 55  
 Zhang C 6  
 Zhang E 94, 113, 119  
 Zhang M 30  
 Zhang X 55  
 Zhang X-L 60  
 Zhao R 55  
 Zhao Y 8



## Notes

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

