

# CONGENITAL CARDIOLOGY TODAY

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## Hybrid Pulmonary Valve Replacement in an Eight-Year-Old: Status Post Tetralogy of Fallot Repair

By Vishal R. Kaley, MBBS, MD; E. Oliver Aregullin, MD, FAAP; Bennett P. Samuel, MHA, BSN, RN; Giedrius Baliulis, MD; Neal D. Hillman, MD; Marcus P. Haw, MBBS, MS, FRCS, FECTS; Joseph J. Vettukattil, MBBS, MD, DNB, CCST, FRCPC, FRSM, FRCP

Abstract presented at poster session of the Grand Rapids Citywide Research Day, Grand Rapids, MI, USA (April 2018): P39 – Hybrid procedure for pulmonic valve replacement in an eight-year old status post Tetralogy of Fallot repair.

**Keywords:** Hybrid procedure; Pulmonary regurgitation; Pulmonary artery banding.

### Introduction

Pulmonary Regurgitation (PR) is observed in up to 80% of patients following Tetralogy of Fallot (TOF) repair.<sup>1</sup> Free PR leads to progressive dilatation of the Right Ventricular Outflow Tract (RVOT), ventricular dysfunction, reduced exercise capacity, arrhythmias, and sudden death.<sup>2</sup> Regular follow-up and timely treatment are required to prevent these complications. Conventionally, these patients are treated by surgical or Transcatheter Pulmonary Valve Replacement (TPVR). Transcatheter intervention is preferred over the surgical approach as it is reported to have better outcomes and fewer complications.<sup>3</sup> However, transcatheter

implantation is challenging in chronic cases with severely dilated RVOT (e.g. >30 mm) due to limitations in sizes of the currently available prosthetic transcatheter pulmonary valves. Various hybrid approaches such as Pulmonary Artery (PA) banding or PA plication to decrease the size of the dilated RVOT to facilitate TPVR have been described.<sup>4,5</sup> We present our experience with the hybrid procedure – PA banding followed by TPVR – to manage an 8-year-old female with dilated RVOT, free PR, left PA stenosis, esophageal varices with protein C and factor VII deficiency status post TOF repair.

### Case Report

An 8-year-old female born with TOF, and having a complex surgical and medical history, was noted to have increased fatigue and shortness of breath for a few months. She was born full term and postnatal transthoracic echocardiogram revealed TOF with small confluent branch PAs. A right Blalock Taussig (BT) shunt with 3.5 mm Gore-Tex tube was placed in the neonatal period due to persistent cyanosis. She was discharged at 1 month of age with oxygen saturation at 85%. She underwent TOF repair with transannular patch, left PA angioplasty, and takedown of BT shunt at the age of 15 months. The post-operative period was complicated by desaturations and hemodynamic instability requiring RV muscle resection and revision of transannular patch.

Upon follow-up at the age of 4 years, an echocardiogram revealed free PR with flow turbulence and increasing gradients in both the

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branch PAs. She underwent cardiac catheterization with balloon angioplasty of the branch PAs with good results. However, she was hospitalized for seizures soon after secondary to intracranial bleeding, and was diagnosed with protein C and factor VII deficiency. During subsequent work-up for abdominal distension and hematemesis, she was also diagnosed with portal vein thrombosis leading to non-cirrhotic portal hypertension and esophageal varices.

At 8 years of age, she was admitted to the Pediatric Intensive Care Unit for hematemesis associated with a significant drop in hemoglobin. During hospitalization, she was also found to be hypoxic with oxygen saturations in the mid-80s. An echocardiogram demonstrated bidirectional shunting across the Atrial Septal Defect (ASD), severe pulmonary valve regurgitation and significant RV dilation. Cardiac magnetic resonance (CMR) confirmed severe RV dilatation with indexed end diastolic volume of 178 mL/m<sup>2</sup> (z-score 9.3) with ejection fraction of 45%, severe PR with regurgitant fraction of 45%, and a moderately-dilated main PA measuring 30 mm in diameter. A multidisciplinary team including pediatric interventional cardiologists, congenital cardiothoracic surgeons, and gastroenterologists recommended Hybrid approach for TPVR to avoid the complications associated with surgical repair and cardioplegic arrest in the setting of coagulopathy and esophageal varices.

**Intervention.** Under general anesthesia and aseptic precautions, the right femoral vein and artery were cannulated using 6F and 4F sheaths respectively. The right- and left-heart catheterization confirmed the CMR findings, including a severely dilated RVOT and free PR (Figure 1). Baseline hemodynamics demonstrated no significant RVOT gradient,

moderate left PA stenosis and mildly increased PA pressure with mean PA pressure of 30 mmHg. Following detailed hemodynamic and angiographic assessment, the left PA was stented using a Genesis 29/10 stent mounted on a 14x35 mm balloon in balloon (BIB) catheter with optimal result (Figure 2). The RVOT was then balloon-sized using a 30 mm PTS sizing balloon. This was followed by a median sternotomy, and off-pump PA band placement using a polyester graft.

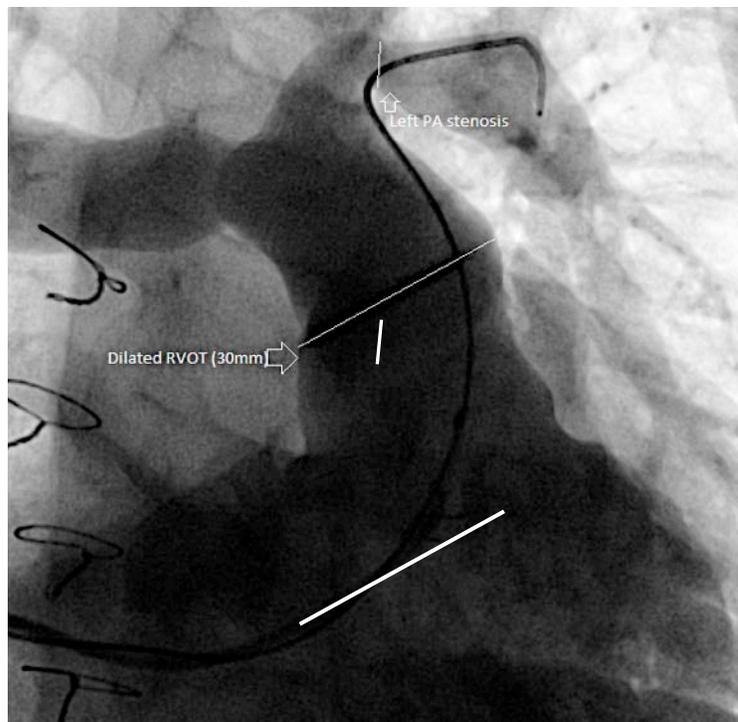


Figure 1. Right ventriculography showing the dilated right ventricular outflow tract and narrow left pulmonary artery, with free pulmonary regurgitation.

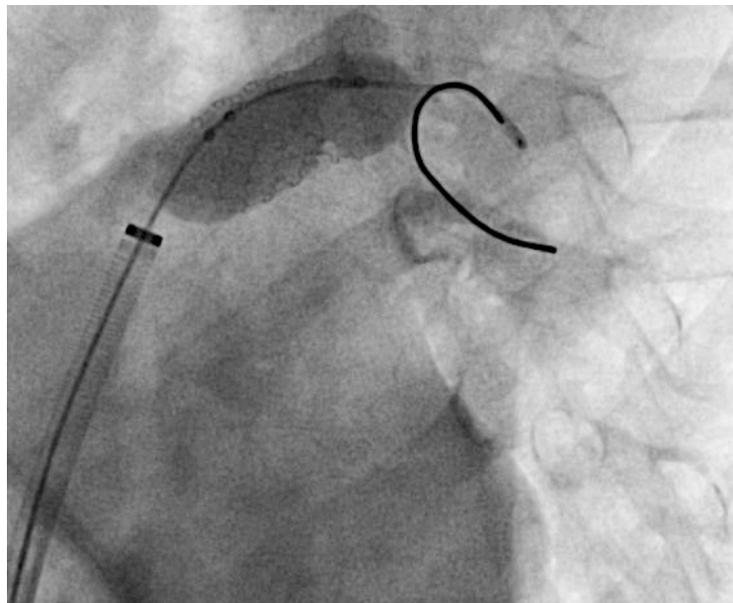


Figure 2. Stenting of the left pulmonary artery using a Genesis 29x10 mm stent mounted on a 14x35 mm balloon-in-balloon catheter.

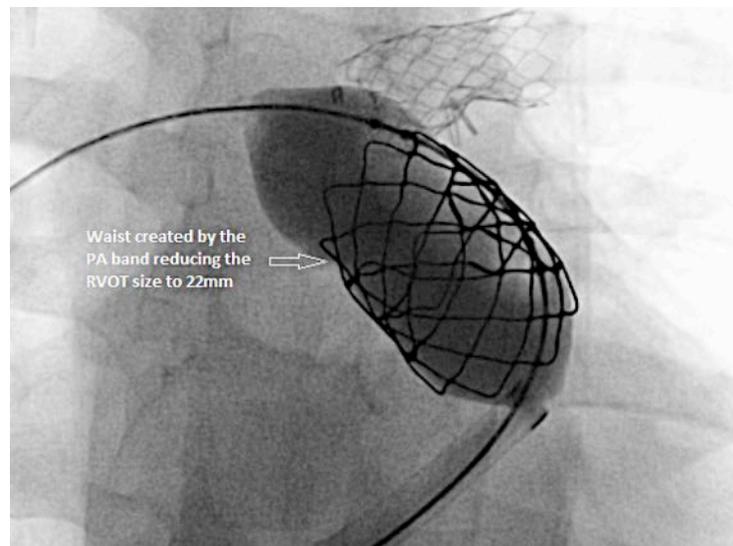


Figure 3. Implantation of a 39 mm Cheatham Platinum bare stent using a 24x40 mm balloon-in-balloon catheter in the modified right ventricular outflow tract (following banding) to create a landing zone for the Melody valve.

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- Assessment of the coronary artery anatomy for the risk of coronary artery compression should be performed in all patients prior to deployment of the TPV.
- To minimize the risk of conduit rupture, do not use a balloon with a diameter greater than 110% of the nominal diameter (original implant size) of the conduit for pre-dilation of the intended site of deployment, or for deployment of the TPV.
- The potential for stent fracture should be considered in all patients who undergo TPV placement. Radiographic assessment of the stent with chest radiography or fluoroscopy should be included in the routine postoperative evaluation of patients who receive a TPV.
- If a stent fracture is detected, continued monitoring of the stent should be performed in conjunction with clinically appropriate hemodynamic assessment. In patients with stent fracture and significant associated RVOT obstruction or regurgitation, reintervention should be considered in accordance with usual clinical practice.

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Potential device-related adverse events that may occur following device implantation include the following: stent fracture, stent fracture resulting in recurrent obstruction, endocarditis, embolization or migration of the device, valvular dysfunction (stenosis or regurgitation), paravalvular leak, valvular thrombosis, pulmonary thromboembolism, hemolysis.

"The term "stent fracture" refers to the fracturing of the Melody TPV. However, in subjects with multiple stents in the RVOT it is difficult to definitively attribute stent fractures to the Melody frame versus another stent.

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**Indications:** The Melody™ TPV is indicated for use in patients with the following clinical conditions:

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- Patients with stenotic prosthetic RVOT conduits or bioprostheses where the risk of worsening regurgitation is a relative contraindication to balloon dilatation or stenting

### Contraindications:

- Venous anatomy unable to accommodate a 22 Fr size introducer sheath
- Implantation of the TPV in the left heart
- RVOT unfavorable for good stent anchorage
- Severe RVOT obstruction, which cannot be dilated by balloon
- Obstruction of the central veins
- Clinical or biological signs of infection
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**Potential Complications/Adverse Events:** Potential procedural complications that may result from implantation of the Melody device include the following: rupture of the RVOT conduit, compression of a coronary artery, perforation of a major blood vessel, embolization or migration of the device, perforation of a heart chamber, arrhythmias, allergic reaction to contrast media, cerebrovascular events (TIA, CVA), infection/sepsis, fever, hematoma, radiation-induced erythema, pain, swelling or bruising at the catheterization site.

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"The term "stent fracture" refers to the fracturing of the Melody TPV. However, in subjects with multiple stents in the RVOT it is difficult to definitively attribute stent fractures to the Melody frame versus another stent.

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The Melody Transcatheter Pulmonary Valve and Ensemble II Transcatheter Delivery System has received CE Mark approval and is available for distribution in Europe.

After angiographic assessment and manipulations of the band, the desired RVOT diameter of 23 mm was achieved as measured by repeated angiography and balloon-sizing. Coronary compression testing was performed with a 24 mm BIB catheter across the RVOT and showed no coronary involvement. To create a landing zone for the transcatheter pulmonary valve, a 39 mm Cheatham Platinum bare metal stent (NuMED, Inc., Hopkinton, NY, USA) was mounted on a 24x40 mm BIB catheter and deployed in the distal RVOT via femoral vein approach (Figure 3). A Melody transcatheter pulmonary valve (Medtronic, Inc., Minneapolis, MN, USA) was successfully implanted at 22 mm inside the stented segment of the RVOT (Figure 4). Post-deployment angiography showed optimal Melody valve position with no regurgitation (Figure 5). Following deployment, the diastolic pressure in the PA improved to 28

mmHg from the pre-deployment pressure of 10 to 12 mmHg. Mean PA pressure was measured at 30 mmHg. In view of high PA pressure, sildenafil was initiated. There were no complications from the procedure; however, due to esophageal varices the patient had a 10-day hospital stay prior to being discharged.

## Discussion

Transannular patch repair of TOF is known to be associated with pulmonary insufficiency and progressive RV dilatation.<sup>3</sup> Most patients require intervention for PR following TOF repair. Conventionally, patients with complicated anatomy or dilated RVOT require a surgical approach for pulmonary valve replacement. In a retrospective study, patients with TOF repair and surgical pulmonary valve replacement were noted to have a 97.7% 30-day survival, 96% survival at three years, and 96% freedom from re-intervention at 10 years.<sup>6,7</sup> However, surgical treatment is associated with morbidity related to the use of cardiopulmonary bypass and myocardial cardioplegic arrest with an operative mortality risk of almost 1% to 3%.<sup>8</sup> In the last decade, catheter-based interventions have been developed for pulmonary valve replacement and are preferred over the surgical approach. The major limiting factor for the use of transcatheter approach is the lack of availability of appropriately-sized bioprosthetic valves. The maximum appropriate RVOT diameter for the use of the Melody valve is 22 mm (outer diameter of 24 mm), and 29 mm for the Edwards SAPIEN XT Transcatheter Heart Valve. Therefore, TPVR may not be feasible in patients with RVOT diameter greater than 29 mm.

Various hybrid approaches have been considered to overcome these limitations.<sup>5,8</sup> Surgical procedures such as plication of the PA or PA banding are performed to make RVOT dimensions suitable for transcatheter deployment of the pulmonary valve.<sup>7</sup> These procedures require minimal mobilization or dissection and the valve is implanted without cardioplegic arrest. Another advantage is reduction in procedure time with lower risk of complications such as bleeding, unintentional injury to the heart, great vessels, and adjacent structures than surgery. A pilot study of 10 patients who underwent off-pump hybrid pulmonary valve replacement following TOF repair were noted to have better results when compared to on-pump conventional surgical pulmonary valve replacement.<sup>4</sup> The hybrid approach was associated with a significant reduction in operating time, blood loss, and blood product use. Furthermore, the patients were noted to have higher postoperative hemoglobin levels compared to patients following on-pump surgical procedure. No complications such as paravalvular leak or severe PR were reported in any of the patients at the time of early follow-up.<sup>4,8</sup>

In our case, the child had dilated RVOT measuring 30 mm rendering her incompatible for TPVR. The presence of multiple comorbidities like bleeding disorder, portal hypertension, and esophageal varices were a contraindication for on-pump surgical pulmonary valve replacement. Therefore, a hybrid procedure was utilized to treat her left PA stenosis, dilated RVOT and severe PR. The hybrid procedure was performed according to plan and the patient recovered well with optimal hemodynamics.

## Conclusion

Our case suggests the Hybrid procedure for PVR can be a safe and feasible alternative for patients with TOF and dilated RVO,T even with other comorbidities. Future studies may be required to evaluate the efficacy and cost effectiveness of the Hybrid approach for pulmonary

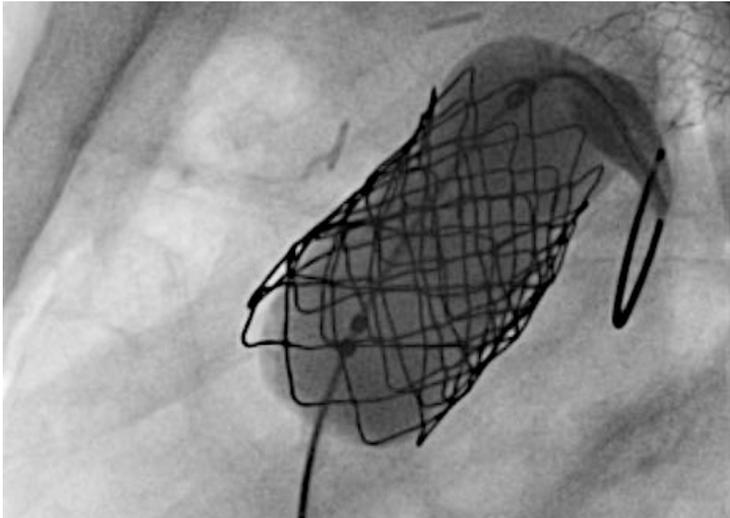


Figure 4. Deployment of the Melody valve in the right ventricular outflow tract.

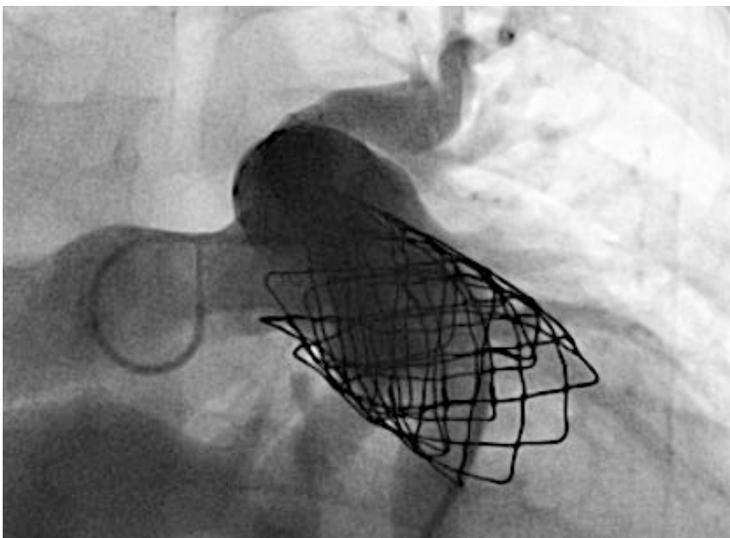


Figure 5. Pulmonary artery injection after the Melody valve implantation showing well placed Melody valve without any pulmonary regurgitation.

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**“Our case suggests Hybrid procedure for PVR can be a safe and feasible alternative for patients with TOF and dilated RVOT even with other comorbidities. Future studies may be required to evaluate the efficacy and cost effectiveness of the Hybrid approach for pulmonary valve replacement over conventional surgical intervention.”**

valve replacement over conventional surgical intervention.

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# SNAPSHOT: The 7<sup>th</sup> Annual Adult Congenital Heart Disease in the 21<sup>st</sup> Century Conference

By Anitha John, MD, PhD

Treating patients with Adult Congenital Heart Disease (ACHD) requires the ability to think quickly, process complex data, and integrate innovation while extrapolating existing data. More importantly, forming a partnership with patients and their families, as well as developing a strong collaborative network

with other ACHD providers and subspecialists is critical to maintaining the health of this growing patient population. Teamwork matters. Delivering precision care at the right time, with the right bedside manner, and keeping the goals of the patient in mind will boost the likelihood each patient lives a long, healthy life. As a Congenital Heart Disease (CHD) specialist, you know this.

You also know the guidelines—while tremendously important for creating standards of care and practice—don't always hold true for each patient. While we utilize the practice guidelines as applicable, in many instances we must create specialized treatment plans, which may vary over time and with each patient. This individualized, team-based approach to treating CHD drives the educational content, breakout sessions, and innovative tools presented to providers at the *Adult Congenital Heart Disease in the 21<sup>st</sup> Century Symposium* each year.



Dr. John, third from right, and the Washington Adult Congenital Heart Program (WACH) gather outside of the College Park Marriott Hotel & Conference Center in Hyattsville, MD. From left-to-right: Seiji Ito, MD; Nancy Klein, RN; Emily Stein, MSW.; Liz Ballew, BA; Ruth Phillippi, MS; Whitney Osborne, MPH; Elaine May, RN; Rachel Steury, RNP; Anitha John, MD, PhD; Tacy Downing, MD; Pranava Sinha, MD.

On April 13<sup>th</sup> to 14<sup>th</sup>, Children's National Health System and MedStar Health hosted its seventh annual continuing medical education (CME) conference at the College Park Marriott Hotel & Conference Center in Hyattsville, MD, and partnered with more than three dozen faculty members to deliver nine sessions to 270 attendees, inclusive of patients, fellows and providers.

The physician-driven content provides up to 13.5 continuing education credits and is accredited by the Accreditation Council for Continuing Medical Education (ACCME), the Accreditation Council for Pharmacy Education (ACPE), and the American Nurses Credentialing Center (ANCC), but we welcome entire medical support teams—from internists, cardiologists, and surgeons to obstetricians and gynecologists, nurses, social workers, and advanced practitioners—who evaluate, diagnose, and manage Congenital Heart Disease care from infancy and late adolescence into adulthood. We are pleased to provide quality ACHD-focused education to medical trainees, including medical students, residents and fellows from varied specialties.



Elijah Goldman and his mother, Julie Farkas, discussed his experiences in medical decision making as an emerging adult (Dr. John, right).

## This Year's Focus: Innovative Treatment Models and Patient Partnerships

Innovation is interwoven into ACHD care as much as it is into our CME conferences. In 2014, Leonard Bailey, MD, a pediatric cardiothoracic surgeon who performed the first infant heart transplant, spoke to attendees about the constant need for medical innovation. It's what saves lives. The following year, in 2015, William Norwood, MD, a cardiothoracic surgeon talked about the Norwood operation, the standard surgery for Stage 1 treatment of Hypoplastic Left Heart Syndrome (HLHS). This year Mark Rodefeld, MD, a cardiothoracic surgeon, delivered the keynote address, "New Innovations: Fontan Blood Pump."

Dr. Rodefeld talked about the history of surgery for patients with single ventricle anatomy, the Fontan operation, and its future implications. The Fontan blood pump,



Mark Roeder, President of the Adult Congenital Heart Association (ACHA), speaks about the future goals for ACHA at the opening session of the patient/family/provider day on Saturday, April 14<sup>th</sup>.



A panel of patients and their families discuss social topics interwoven into ACHD treatment and care at the inaugural 'Patient/Family Day' at the 7<sup>th</sup> Annual Adult Congenital Heart Disease in the 21<sup>st</sup> Century Conference.

designed by Dr. Rodefeld, attempts to replace the missing pump and restore the Fontan circulation to a more efficient 2-ventricle circulation. If successful, the technology will make it possible to permanently reverse the Fontan paradox, maintain biventricular health, and preempt the relentless progression of Fontan disease. While the Fontan blood pump isn't ready for the market yet, Dr. Rodefeld's talk laid the groundwork for the afternoon sessions, discussing innovative surgical and medical strategies and the potential for research collaborations, sparking new ideas and hope for the future.

Other panels focused on cardiac catheterization, 3D heart models, and noninvasive surgical techniques, such as lymphatic imaging and therapy models.

Patient advocate Elijah Goldman and his mother, Julie Farkas, talked to attendees about how the care Goldman received throughout his lifespan, including the process of transitioning to adult-based care, impacts their lives today.

#### **Personalized Patient Care and Partnering with Patients/Families**

In addition to hearing from Goldman on Friday, April 13<sup>th</sup>, more than 70% of the healthcare provider attendees joined over 100 patients and family members on Saturday, April 14<sup>th</sup>, at the inaugural 'Family/Patient Day' to learn about practical topics that impact patient lives. These included topics such as: navigating health insurance, filing for disability, establishing independence as an

adult patient, and how to find appropriate medical care. Patient advocate Scott Leezer set the stage for the day by presenting his personal perspective about the importance of transition and staying in care.

The providers and patients enjoyed participating in joint seminars, which were designed to provide patients with take-home resources in addition to facilitating discussion with other patients and providers. Topics included CHD and the family, innovations and advances in ACHD care and research, and women's health issues, such as family planning options for ACHD patients.

The women's health session featured providers who gave information about family planning options – such as in vitro fertilization (IVF), adoption and surrogacy – and patients who shared their experiences with the various methods of building a family. The session also focused on body image and empowerment with a wonderful presentation by patient advocate Shelvee Brown and her journey regarding self-acceptance and fitness. The session sparked a robust discussion about a variety of issues, including dating as a CHD patient, accepting your scars, and increasing physical fitness and strength.

Many patients brought family members and were able to learn more about the latest science with their loved ones, shedding new light on a variety of topics and considerations they can apply at home, like talking to their children about what it means to live with heart disease and how to successfully manage ongoing medical care.

#### **Social Networks**

One of the strengths of this conference is the social networks it establishes. In addition to helping physicians meet fellows, colleagues, and regional providers, attendees enjoy connecting with faculty from Children's National and numerous institutions. Patients appreciate this peer networking aspect, too. In addition to the ability to discuss the latest medical innovations with attending doctors, they had the opportunity to speak with one another and engage with patient panelists about their presentations, sharing their collective experiences on being a patient with Congenital Heart Disease. Younger adolescent patients and their parents were able to connect with adults with similar

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<sup>1</sup> "International Multicentre Clinical Device Investigation on Safety and Effectiveness of the Nit-Occlud® Lê VSD Spiral Coil System for VSD Occlusion" (clinicaltrials.gov identifier NCT00390702).

<sup>2</sup> "The Nit-Occlud® Lê VSD Registry", publication in preparation.

heart issues, which further empowered patients and families to see what is possible in the future.

The conference relies heavily on the participation of the Mid-Atlantic ACHD regional group of providers. Established in 2011 through Children's National, the group has expanded to include ACHD providers from over 18 programs/practices from across the East Coast. This group provides a forum for patient case discussion and programmatic support. More importantly, the collegiality and collaboration has served to not only improve patient care, but also provide support to providers as they continue to care for a growing population of patients. This type of collaboration fosters mutual understanding, and sets the stage for a relaxed, but collegial environment where questions flow and learning occurs.

A shared sentiment among all attendees is that collaboration has replaced the old model of isolation and competition. It is increasingly recognized that we are all much stronger working together. In addition to sparking research ideas and elevating standards of care, this unified approach to learning empowers patients and providers.

## Resources

To reserve a place at the 8<sup>th</sup> Annual Adult Congenital Heart Disease in the 21<sup>st</sup> Century Conference, which will be held in the spring of 2019 in the Washington area, please send an email to: [medstarcme@gmail.com](mailto:medstarcme@gmail.com).

To join the Mid-Atlantic ACHD mailing list, please send an email to: [AnJohn@childrensnational.org](mailto:AnJohn@childrensnational.org). At our next conference meeting, we will be expanding on the women's health topics. For more information, or to reserve a space, please send an email to: Ruth Phillippi at [RPhillip@childrensnational.org](mailto:RPhillip@childrensnational.org). A teleconference option is available, and the group is open to those living outside of the mid-Atlantic region.

## CCT

Anitha S. John, MD, PhD, is the course director of the annual *Adult Congenital Heart Disease in the 21<sup>st</sup> Century CME Conference* and the Director of the Washington Adult Congenital Heart Program (WACH), a joint partnership between Children's National Health System and Medstar Washington Hospital in Washington, DC.



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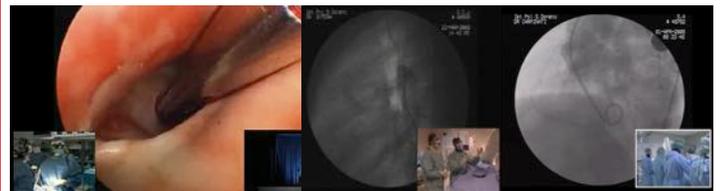
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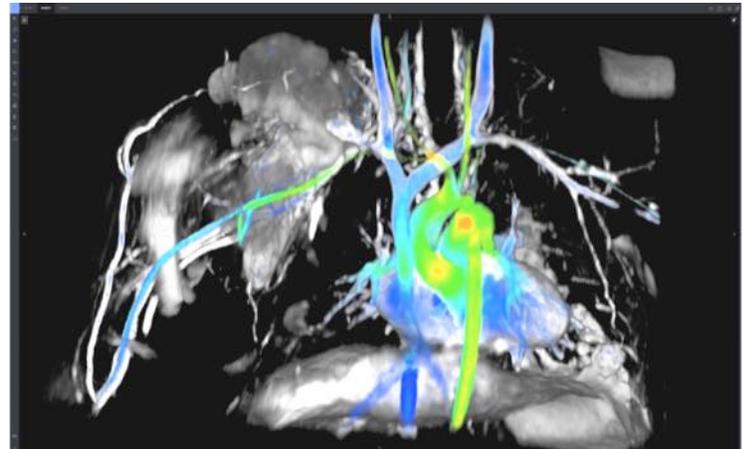
# Artificial Intelligence in Medicine (AIMed) Symposium: Embracing a New Paradigm in Healthcare and Medicine - December 11<sup>th</sup>–14<sup>th</sup>, 2017, in Dana Point, CA

By Nathaniel E. Bischoff, BS; Addison Gearhart, MD; Anthony C. Chang, MD, MBA MPH, MS

**Key Words:** Algorithms, Artificial Intelligence, Big Data, Deep Learning, Machine Learning

It is difficult to predict the future of healthcare in the next 20 years as medical artificial intelligence (AI) technologies become increasingly affordable, robust and accurate. However, it becomes even more difficult to imagine a future in healthcare, especially in a complex discipline like cardiology, not driven by AI. The future gold standard prototypical AI system would provide the clinician with instantaneous access to all relevant information on a patient before he or she walked into the exam room. Information on that patient would come from data retrieved from wearable technology, family history, genetic testing, demographics, past medical history and the Electronic Medical Record (EMR). Today, AI systems are narrow, meaning the systems can only complete one task, but show promise for a futuristic state in which a complete picture on diagnoses, treatment, and prevention of diseases, unique to each patient, will be accessible for the clinical care team. Roadblocks to AI advancements in medicine have highlighted a need for strong engagement between the diverse stakeholders - clinicians, patients, data scientists, hospital administration, and investors. *The Artificial Intelligence in Medicine (AIMed) Symposium* was created to facilitate that collaboration to advance this field.

*The Second Annual AIMed Symposium* was held December, 2017, in Dana Point, CA at the Ritz Carlton Hotel. Dr. Anthony Chang, the Medical Director of the Medical Intelligence and Innovation Institute at Children's Hospital of Orange County, and conference chair of *AIMed*, welcomed over 500 attendees from multidisciplinary backgrounds representing more than 20 countries and over 60 faculty members from top-ranking academic centers. Historically, AI conferences on



***“It is difficult to predict the future of healthcare in the next 20 years as medical artificial intelligence (AI) technologies become increasingly affordable, robust and accurate. However, it becomes even more difficult to imagine a future in healthcare, especially in a complex discipline like cardiology, not driven by AI.”***

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medicine attracted primarily data scientists and technology startups, overlooking a key demographic - the healthcare providers. In the first two years, over 40% of AIMed attendees are practicing clinicians.

The first day featured interactive small group workshops led by experts. Catering to the diversity in participant familiarity with AI applications in medicine, topics ranged from the basics of data and databases to updates on the advancements in cognitive computing and natural language processing.

Dr. Chang's keynote kicked off the conference with thought-provoking insights and a fast-paced overview of the symposium, getting attendees ready to participate both live and with technology, using the AIMed application or texting. The proceeding days were spent listening to short TED-like presentations and panel discussions on current and future applications in the six integral areas of AI:

- Decision Support & Hospital Monitoring
- Medical Imaging & Biomedical Diagnostics
- Precision Medicine & Drug Discovery
- Cloud Computing & Big Data
- Digital Medicine & Wearable Technology, and
- Robotic Technology & Virtual Assistants.

Each section reviewed was followed by open Q&A discussions with audience members. Attendees jumped at the opportunity to pick the brains of the champions of AI and offer input unique to how AI affects their chosen field. There was more information and excitement than time. The energy was contagious and often conversations carried on outside the conference.

Common themes addressed were the intersection between cardiology and AI and the heavy emphasis on AI-driven technology in medical imaging. Some of the notable projects include research groups from MIT and Stanford, among others, extracting information using Natural Language Understanding (NLU) from cardiology notes and echocardiogram (ECG) reports. NLU is a concept within AI that extracts meaning and compression from written or typed physician notes and produces a desired output such as a summary of the note. Clinicians and data scientists from Cardiovascular ICUs (CVICU) around the world are collaborating to apply AI algorithms to data derived from vital signs, electronic medical records and patient monitors to predict patient deterioration and adverse cardiac events.

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Sincerely,

Gary Webb, MD  
**CHI<sup>P</sup> Network**  
 215-313-8058  
[garywebb6@gmail.com](mailto:garywebb6@gmail.com)



The CHI<sup>P</sup> Network, the Congenital Heart Professionals Network, is designed to provide a single global list of all CHD-interested professionals.



**Archiving Working Group**  
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Leaders discussed a new horizon in medical imaging with use of cloud-based, automated systems to analyze ECGs. Other speakers discussed the benefits and risks of wearable technologies for cardiology patients. Diagnostic tools in devices such as the Apple Watch are currently being used to monitor patients and detect abnormalities in heart rhythms. Startups and large corporations are currently collaborating to create augmented and virtual reality (AR and VR) systems to plan in interventional and pediatric cardiology surgery, and find new ways to view and analyze patient scans. Discussions with panelists emphasized the groundbreaking advancements in the academics of deep learning, as well as limitations in the clinical implementation of these technologies.

Highlights from the conference included sunset breaks overlooking the Pacific Ocean, abstract competitions and the inauguration of AIMed Beach. AIMed Beach was a competition, modeled after the TV show *Shark Tank*, that provided a forum for five AI-related startups to pitch their ideas before the audience, and an investor group.

This year over 150 abstracts were submitted, a 67% increase from last year. The abstracts were presented during the appetizers and e-poster event. Abstract winners were awarded prizes including a free stay, and their work was showcased in front of the future AIMed audience.

The main takeaway from AIMed 2017 was emphasized as a need for collaboration between all AI stakeholders – healthcare providers, patients and their families, machine learning engineers, cognitive computing scientists, hospital administrators and more. Ultimately, with an interdisciplinary approach, we as a medical AI-community can develop innovative solutions to identified

problems that are realistic, helpful and pertinent to clinical practice while maintaining and preserving the patient-doctor human relationship. The second main takeaway was to understand the limitations and applications for AI in Medicine. Many speakers mentioned the current hype around different forms of deep learning, such as deep and convolutional neural networks. The final takeaway was AI and medical practitioners must go beyond using deep learning techniques to combine different methods, such as cognitive systems and social sciences, to ensure daily clinical medicine is at the forefront of algorithmic development. The conference concluded with a forum on innovative future application of AI in healthcare. Participants left with a renewed excitement around their individual

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***“For more information on AIMed, visit the website (<http://www.ai-med.io/>) for all slides and videos from AIMed 2017 in addition to an e-book on AI in Medicine. In 2018, AIMed is expanding to Europe and Asia in September and November respectively. The main U.S. AIMed will be held on December 12<sup>th</sup> – 15<sup>th</sup> of 2018, in California.”***

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passions for AI and for the possibilities of new connections, ideas and discoveries.

For more information on AIMed, visit the website (<http://www.ai-med.io/>) for all slides and videos from AIMed 2017 in addition to an e-book on AI in medicine. In 2018, AIMed is expanding to Europe and Asia in September and November respectively. The main U.S. AIMed will be held on December 12<sup>th</sup> – 15<sup>th</sup> of 2018 in California.

*Conflicts of interest: The authors have no conflicts of interest to disclose.*

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# Remembering the Female Clinicians Who Revolutionized Pediatric Cardiology

By Jacqueline Kreutzer, MD

*Editor's Note: The following speech served as the Mullins Lecture on women in medicine, which was presented at the Society for Cardiovascular Angiography and Interventions (SCAI) 2018 Scientific Sessions (4/25–4/28).*

Pediatric Cardiology, as a subspecialty, was founded by women at the start of the 20<sup>th</sup> century. At a time when medicine was a man's game, several female physician pioneers overcame countless obstacles by virtue of their intellect and persistence to build the basis of Congenital Heart Disease (CHD) care today. In this lecture, through a historical review, I outline their contributions.

First to recognize is Dr. Maude Abbott, who in 1936 published the famous Atlas of Congenital Cardiac Disease. Recognized as a landmark reference textbook, Dr. Abbott described and classified 1,000 heart specimens, with correlation between congenital cardiac anatomy and clinical findings including electrocardiography. She also included novel concepts of comparative anatomy, suggesting that defective heart development was responsible for the resulting heart defect.

Dr. Helen Taussig is considered the "Mother of Pediatric Cardiology," as she was the pioneer who established the subspecialty as such. In the early 1900's there were no pediatric cardiologists. Few pediatricians had developed an interest in Rheumatic Fever, but the true understanding of Congenital Heart Disease allowing therapeutic breakthroughs, we owe to Helen Taussig. Her biggest contribution was the design of an operation which allowed the increase pulmonary blood flow in children with severe cyanosis and would become lifesaving. The same procedure is performed today on a regular basis all over the world, in a modified fashion, while the essence of the palliative procedure remains exactly the same (This is the Blalock Taussig shunt.). In addition, Dr. Taussig was a devoted teacher. She initiated a fellowship in Pediatric Cardiology, through which she trained the future pioneers and medical leaders in the field.

Among her fellows, Dr. Mary Allen Engle became the first director of Pediatric Cardiology at what is now New York-Presbyterian Hospital/Weill Cornell Medical Center. She was instrumental in creating the Division of Pediatric Cardiology, which she ran for 30 years, and was later named in her honor. She is credited with many research breakthroughs, including the use of gamaglobulin for therapy in Kawasaki Disease, heart failure secondary to left to right shunt in Ventricular Septal Defects (VSD), and the long-term complications of the Mustard operation. She also helped establish Pediatric Cardiology as the first subspecialty section in the American Academy of Pediatrics in 1957, and played a key

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***"Pediatric Cardiology as a subspecialty was founded by women at the start of the 20th century. At a time when medicine was a man's game, several female physician pioneers overcame countless obstacles by virtue of their intellect and persistence to build the basis of Congenital Heart Disease (CHD) care today. In this lecture, through a historical review, I outline their contributions."***

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role in the organization of the *World Congress of Pediatric Cardiology* in New York City in 1985.

Dr. Stella Van Praagh was a very relevant figure in our field, given her dedication to education and major contributions to the understanding of various complex and simple heart defects. Stella was born in Crete, Greece, and after graduating in Athens, came to the U.S. for medical training. She was a fellow under Helen Taussig, and also did training with John Keith in Toronto. She married Dr. Richard Van Praagh in 1962, and with him, developed the Cardiac Registry at Boston Children's, as a center for advancing the understanding of the pathology of Congenital Cardiac Disease. She authored more than 100 scientific publications, lectured and taught trainees in cardiology and cardiac surgery from all over the world. She possessed the clarity of thought and language that made even the most complicated of cardiac malformations comprehensible to everyone.

Across the Atlantic, Dr. Jane Somerville became a leader in the field in London, England, with her teachings and influence soon expanding all over the world. She was mentored by pioneers like Dr. Paul Wood. She developed expertise in primarily pediatric cardiology, especially congenital heart surgeries. The classification of pulmonary atresia with VSD goes with her name. She carries the credit of creating the idea of a common scientific session involving both Pediatric Cardiology and Cardiac Surgery, which has translated over time into the *World Congress of Pediatric Cardiology and Cardiac Surgery*. She is the founder of the GUCH (Grown-Up Children with Congenital Heart Disease), known in the U.S. as Adult Congenital Heart Disease, as a subspecialty within cardiology.

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A particular pioneer woman physician to recognize in the field of Interventional Pediatric Cardiology is Dr. Jean Kan, whose major contribution was the groundbreaking paper on pulmonary valve balloon dilation in 1982. Following this breakthrough, the field of Interventional Cardiology expanded with growing discoveries in the use of balloon angioplasty and valvotomy procedures applied to Congenital Heart Defects.

Dr. Roberta Williams was a pioneer in the field of Echocardiography since the early 70s, defining the initial correlations between anatomy and echocardiography to allow for accurate diagnosis - necessary for surgical repair and catheter intervention. She founded the Echo Lab at Boston Children's in 1973, and was the first Medical Director of a dedicated Pediatric Cardiac Intensive Care Unit there. She then became Chief of Pediatric Cardiology in UCLA, and was dedicated to education and training, playing key leadership roles at several prestigious institutions, including the American Academy of Pediatrics.

It is also important to recognize Dr. Jackie Noonan, known internationally for her description of what is known as Noonan's Syndrome. We also owe to her some pivotal contributions in the early 70s, including the first original description of 101 patients with Hypoplastic Left Heart Syndrome. Following her training in Boston, she served for 39 years as Director of Pediatric Cardiology in the University of Kentucky.

Dr. Maria Victoria de la Cruz was a female pioneer, who in 1956 proposed the revolutionary concept of applying the principles of embryology to the interpretation of Complex Congenital Heart Disease (CCHD), the result of irreversible developmental errors. During the 60's and 70's, she completed experimental studies on insults on the embryonic heart.

Throughout the country there were other women physicians with leadership roles at several institutions in the U.S. Some had been former Helen Taussig's fellows. Among these, Dr. Ruth Whittemore, a Yale professor who conducted groundbreaking research in Pediatric Cardiology based on data from clinics she founded in 1940's. A major contribution was her population study on the genetics of Congenital Heart Disease.

Charlotte Ferencz, who was also an ex-Helen Taussig fellow, was principal investigator for the regional Baltimore-Washington Infant Study, a population based study of Congenital Heart Disease.

There were several other women pioneers, including: Grace Wolff (pioneer in Pediatric Electrophysiology, author of seminal studies on Wolff-Parkinson-White (WPW) Syndrome, sudden death after Tetralogy of Fallot repair), recipient of the Pediatric and Congenital Electrophysiology Society (PACES) Life Achievement Award, Janet Baldwin, Eugenia Doyle, Sylvia Preston Griffiths, Cora Lenox, and more. They all paved the way to how we practice medicine today, and helped empower many more women leaders in the field who followed with major contributions, including: Jane Newburger, Vickie Vetter, Robyn Barst, and many more women.

### CCT

This story was first published on Doximity, April 30, 2018. The link to the original article is below, and this story is republished here with permission.

<https://opmed.doximity.com/remembering-the-female-clinicians-who-revolutionized-pediatric-cardiology-a557e800f935>



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## UPCOMING MEDICAL MEETINGS

**2018 Fetal Cardiac Symposium**  
July 12-13, 2018; Chicago, IL USA  
[www.fetalcardiacsymposium.com](http://www.fetalcardiacsymposium.com)

**6th Scientific Meeting of the World Society for Pediatric and Congenital Heart Surgery (WSPCHS)**  
July 22-26, 2018; Orlando, FL USA  
<http://www.cvent.com/events/6th-scientific-meeting-of-the-world-society-for-pediatric-and-congenital-heart-surgery/event-summary-7f53a0c01ccd45cf86a739b3ac5d15db.aspx>

**International Academy of Cardiology, 23rd World Congress on Heart Disease, Annual Scientific Sessions 2018**  
July 27-29, 2018; Boston, MA USA  
[www.cardiologyonline.com/wchd2018/](http://www.cardiologyonline.com/wchd2018/)

**28th International Conference on Cardiology and Healthcare Cardiology Meetings - Sharing the Vision in Cardiology and Healthcare Research**  
Aug. 9-11, 2018; Abu Dhabi, UAE  
<https://healthcare.cardiologymeeting.com>

**American Academy of Pediatrics Specialty Review in Pediatric Cardiology Course**  
Aug. 13-17, 2018; Chicago, IL USA  
Contact [vthorne@aap.org](mailto:vthorne@aap.org) for more information.

**2018 Pediatric and Adult Congenital Cardiology Review Course**  
Aug. 19-24, 2018; Dana Point, CA USA  
[ce.mayo.edu/internal-medicine/content/2018-pediatric-and-adult-congenital-review-course](http://ce.mayo.edu/internal-medicine/content/2018-pediatric-and-adult-congenital-review-course)

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# Review: SCAI 2018 Annual Scientific Sessions

By Dennis W. Kim, MD

The 2018 Society of Cardiovascular Angiography and Interventions (SCAI) Annual Scientific Session was held April 25<sup>th</sup>-27<sup>th</sup> at the Manchester Grand Hyatt in San Diego. As typical, the weather in San Diego did not disappoint, but the Congenital Heart Disease Track gave conference attendees more than enough reason to stay indoors. Practical and useful knowledge to bring home was the theme of the congenital sessions with case-based presentations followed by in depth discussions, providing new tools and strategies for the conference attendees.

Leading off the Congenital Heart Disease track was “Pulmonary Vein Stenosis: Mission Impossible?” With the continuing increase in infants born with extreme prematurity, the numerous congenital heart diagnoses with associated pulmonary vein problems, continuing prevalence in the adult population after left atrial electrophysiologic ablation therapy, as well as the difficulties in achieving good long-lasting surgical results, this emerging group of patients is particularly challenging for interventionalists. Continuing Day 1, “The Known Unknowns: Tips and Tricks,” focused on periprocedural anticoagulation strategies, vessel recanalization methods, vascular embolization tips, acute thrombus removal,

***“With the continuing increase in infants born with extreme prematurity, the numerous congenital heart diagnoses with associated pulmonary vein problems, continuing prevalence in the adult population after left atrial electrophysiologic ablation therapy, as well as the difficulties in achieving good long-lasting surgical results, this emerging group of patients is particularly challenging for interventionalists.”***

and “unzipping” of undersized intravascular stents. Coronary Interventions in Pediatrics highlighted the movement of coronary procedures into the pediatric realm. New techniques in imaging and procedural performance must be understood by all pediatric interventionalists. A spirited discussion of the role of the pediatric vs. adult interventionalist in taking the lead on these complex cases ended this session. Concluding the first day, “3D Imaging for Interventions” introduced the audience how new methods of preprocedural 3D printing, CT/MRI fusion overlay capabilities, and rotational imaging could be used to maximize success and minimize radiation exposure. MRI-guided cardiac catheterization may well emerge to allow the full compliment of procedure types to be successfully performed in a radiation-free environment.

Right ventricular outflow tract abnormalities are among the most common encountered in congenital cardiology. Transcatheter Pulmonary Valve Replacement (TPVR) has proven to be a true game-changer in the treatment of pulmonary valve disease, providing a minimally invasive method to restore pulmonary valve function. The wide variety in morphology of these reconstructed outflow tracts challenge even the most seasoned interventionalist in developing creative methods for procedural success. Day 2 of SCAI 2018 opened with TPVR: Beyond the Basics. Assessing large outflow tracts that challenge the existing FDA-approved TPVR systems, understanding the mechanical nuances of the individual valve systems, channeling our inner “MacGyver” by modifying valve systems, and intentional fracturing of surgical bioprosthetic valves can widen the scope of potential implantation sites. TPVR devices for large outflow tracts

are on the horizon, both developed in the US, as well as overseas. The ultimate goal of all of these devices is to improve patient symptoms and cardiac function, and to reduce the total number of open surgical procedures that will have to be done over a patient’s lifetime. The past decade has only given us a glimpse of the possibilities for the future.

Transseptal puncture is a technique developed in the pediatric world, and has extended to a wide variety of adult structural procedures. Getting from here-to-there is sometimes sounds simple in theory, but often can be quite difficult. “The Transseptal Puncture: Advanced Techniques” illustrated specialized tools, the benefits of assistive imaging, and specific puncture site selection for a variety of left-sided procedures. Sometimes other vascular areas require



Dr. Jacqueline Kreuzer delivering the 2018 Mullins Lecture



Engaged learners at SCAI 2018

specialized puncture strategies- beware of the interventionalist with a long needle!

Clearly, one of the highlights of *SCAI 2018* was "The Mullins Lecture." This is the keynote lecture for the Congenital Heart Disease track, and is given by a luminary in the field of Pediatric Interventional Cardiology. We were once again graced with the presence of Dr. Charles Mullins. The field of Pediatric Cardiology was founded by, and has been influenced throughout its history by women of remarkable will, intellect, and vision. Dr. Jacqueline Kreutzer from the Children's Hospital of Pittsburgh, delivered a stirring lecture highlighting the achievements of women over the past century in our field. From Dr. Maude Abbott's famous "Atlas of Congenital Cardiac Disease," to Dr. Helen Taussig's contribution to the operation that bears her name, to Dr. Mary Allen Engle's development of Pediatric Cardiology as the first subspecialty section in the *American Academy of Pediatrics*, to Dr. Stella Van Praagh's formal classification system of cardiac malformations, and to the many women who continue to develop and advance our field today, pediatric cardiology, perhaps more than any other medical subspecialty, has been impacted by the contributions of women.

Over 40 abstracts were presented at this years meeting. The top five were selected as oral presentations in "Abstracts: Best of the Best." In a very competitive contest, Dr. Varun Aggarwal from Texas Children's Hospital received the award for the best CHD abstract for his investigation in the efficacy of drug eluting stents in infants with ductal dependent pulmonary blood flow, who undergo stenting of the ductus arteriosus.

Concluding the second day of *SCAI 2018* was a perennial favorite, the "I Blew It!" session. Despite the tongue-in-cheek title and the witty and interactive case presentations, these cases present real world scenarios that challenge even the most skilled interventionalist in achieving a good outcome. In his case presentation, "Thankful That I Had Dinner With the Family That Night," Dr. Osamah Aldoss of the University of Iowa Children's Hospital described a lengthy postoperative procedure that illustrated the determination, clear thinking, decisive action, and modesty necessary to ultimately result in success.

What's old can be new again? The surgical treatment of Tetralogy of Fallot (TOF) began the era of surgical repair of Congenital Heart Disease with the original Blalock-Taussig shunt in 1944. The final day of the Congenital Heart Disease Track at *SCAI 2018* began with a reevaluation of the treatment algorithm for neonates born with TOF. Traditionally, for symptomatic infants, surgical procedures, such as palliative aortopulmonary shunts or more recently, complete neonatal repair, have been the mainstays of treatment. However, newer transcatheter methods, such as ductal

or right ventricular outflow stenting also bear promise in the overall strategy for the treatment of this common cardiac disorder. A lively debate ensued between an interventional cardiologist, Dr. Lee Benson of the Hospital for Sick Children in Toronto and a cardiac surgeon, Dr. John Nigro of Rady Children's Hospital, San Diego. It was clear that both debaters, as well as the audience, ended up as winners at the conclusion of this session.

Young interventionalists represent the future of pediatric interventional catheterization, and will pave the way for exciting new groundbreaking therapies. In "The Young Guns: Bullets and Blanks," members of the *Pediatric Interventional Cardiology Early Career Society (PICES)* focused on the needs of the younger interventionalist with case-based presentations demonstrating the merits of aggressive approaches, as well as more prudent ones. Two senior interventionalists, Drs. Phillip Moore and Larry Latson shared their wisdom and perspectives on decision-making skills for young interventionalists.

The final afternoon was devoted to combined Congenital Heart Disease (CHD) and adult Structural Heart Disease (SHD) sessions. It could be said that the practice of Pediatric Interventional Cardiology represents the original form of Structural Heart Disease therapies. These two specialties share many common approaches and techniques, and the future will see further cross-fertilization between these interventional specialties. "Learning From Each Other" showcased six different case-based interventional procedures which could take place in either CHD or SHD cath labs. Each procedure was paired to a CHD and SHD interventionalist, who shared their unique perspectives on these specific procedures.

Rounding out the main sessions at *SCAI 2018* was the keynote address given by Dr. Roberto Canessa. As a 19-year old member of an Uruguayan rugby team, he was one of



*Dr. Roberto Canessa delivering the Keynote Address*

sixteen survivors of an airplane crash in the Andes mountains in 1972. His compelling story of tragedy, survival, hunger ultimately

resorting to cannibalism, and his seemingly hopeless, but relentless trek through the upper Andes with a fellow teammate to seek help riveted the audience. Almost unbelievably, the survivors were rescued after 72 days in the high Andes. His story was memorialized in his book *I Had to Survive* and in the 1993 movie *Alive*. Dr. Canessa went on to become a prominent Pediatric Cardiologist specializing in Echocardiography and Prenatal Diagnosis of Congenital Heart Disease. His humble views on life, death, and his approach to the art of medicine were an inspiration to all.

*SCAI 2018* was an event to be remembered. The vibrant atmosphere of teaching, learning, seeing old friends, and forging new relationships within the cardiology community, makes the *SCAI Annual Scientific Sessions* a leading meeting for Interventional Cardiology.

The *SCAI 2019 Annual Scientific Sessions* will be held at the Cosmopolitan of Las Vegas from May 20-23, 2019. For more information, visit [www.scai.org](http://www.scai.org). For membership information and fellowship applications, visit [www.scai.org/Join](http://www.scai.org/Join).

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***"The SCAI 2019 Annual Scientific Sessions will be held at the Cosmopolitan of Las Vegas from May 20-23, 2019. For more information, visit [www.scai.org](http://www.scai.org)."***



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# Medical News, Products & Information

Compiled and Reviewed by Kate Baldwin, Special Projects Editor

## Higher Blood Sugar in Early Pregnancy Raises Baby's Heart-Defect Risk

Higher blood sugar early in pregnancy raises the baby's risk of a Congenital Heart Defect (CHD) even among mothers who do not have diabetes, according to a study led by researchers at the Stanford University School of Medicine.

The study will be published online Dec. 15<sup>th</sup>, 2018 in *The Journal of Pediatrics*.

For many years, physicians have known that women with diabetes face an increased risk of giving birth to babies with heart defects. Some studies have also suggested a link between non-diabetic mothers' blood sugar levels and their babies' heart defect risk. However, the new study is the first to examine this question in the earliest part of pregnancy, when the fetal heart is forming.

"Most women who have a child with Congenital Heart Disease are not diabetic," said the study's senior author, James Priest, MD, Assistant Professor of Pediatric Cardiology. "We found that in women who don't already have diabetes or develop diabetes during pregnancy, we can still measure risk for having a child with Congenital Heart Disease by looking at their glucose values during the first trimester of pregnancy."

The study's lead author is Emmi Helle, MD, PhD, an affiliate in Pediatric Cardiology and a former postdoctoral scholar.

*A research challenge:* One challenge associated with conducting the research was the fact that maternal blood glucose is not routinely measured in non-diabetic pregnant women. Instead, women typically receive an oral glucose tolerance test halfway through pregnancy to determine whether they have gestational diabetes, but this test is performed well after the fetal heart has formed.

The research team studied medical records from 19,107 pairs of mothers and their babies born between 2009 and 2015. The records included details of the mothers' prenatal care, including blood test results and any cardiac diagnoses made for the babies during pregnancy or after birth. Infants with certain genetic diseases, those born from multiple pregnancies and those whose mothers had extremely low or high body-mass-index measures were not included in the study. Of the infants in the study, 811 were diagnosed with CHD, and the remaining 18,296 were not.

The scientists analyzed blood glucose levels from any blood sample collected from the mothers between four weeks prior to the estimated date of conception and the end of the 14<sup>th</sup> gestational week, just after the completion of the first trimester of

pregnancy. These early blood glucose measurements were available for 2,292, or 13%, of women in the study. The researchers also looked at the results of oral glucose tolerance tests performed around 20 weeks of gestation, which were available for 9,511, or just under half, of the women in the study.

*When risk is elevated:* After excluding women who had diabetes before pregnancy or who developed it during pregnancy, the results showed that the risk of giving birth to a child with a congenital heart defect was elevated by 8% for every increase of 10 milligrams per deciliter in blood glucose levels in the early stages of pregnancy.

"The next step in the research is to conduct a prospective study that follows a large group of women through pregnancy to see if the results are confirmed," said Priest. If researchers see the same relationship, it may be helpful to measure blood glucose early in pregnancy in all pregnant women to help determine which individuals are at greater risk for having a baby with a heart defect, he said.

"We could use blood glucose information to select women for whom a screening of the fetal heart could be helpful," Priest said, adding that modern prenatal imaging allows for detailed diagnoses of many Congenital Heart Defects before birth. "Knowing about defects prenatally improves outcomes because mothers can receive specialized care that increases their babies' chances of being healthier after birth."

The work is an example of Stanford Medicine's focus on precision health, the goal of which is to anticipate and prevent disease in the healthy, and precisely diagnose and treat disease in the ill.

The study's other Stanford co-authors are Joshua Knowles, MD, PhD, Assistant Professor of Medicine; data analyst Wei Yang; Gerald Reaven, MD, Emeritus Professor of Medicine; and Gary Shaw, DrPH, Professor of Pediatrics.

Priest is a member of the Stanford Child Health Research Institute, the Stanford Cardiovascular Institute and the Stanford Neurosciences Institute.

Researchers at Geisinger Health System in Danville, Pennsylvania, also contributed to the study. Stanford's Department of Pediatrics also supported the work. For more information: <http://med.stanford.edu>.

The study was funded by the National Institutes of Health (grant K99HL130523), the Stanford Cardiovascular Institute, the Centers for Disease Control and Prevention (Center of Excellence Award U01DD001033), the Finnish Medical Foundation, Finnish Foundation for Cardiovascular Research, Biomedicum Foundation, Finnish Foundation for Pediatric Research, Orion Research Foundation and the Thrasher Research Fund.



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## Ultrasound Imaging Needle to Transform Heart Surgery

Heart tissue can be imaged in real-time during keyhole procedures using a new optical ultrasound needle developed by researchers at UCL and Queen Mary University of London (QMUL).

The revolutionary technology has been successfully used for minimally invasive heart surgery in pigs, giving an unprecedented, high-resolution view of soft tissues up to 2.5 cm in front of the instrument, inside the body.

Doctors currently rely on external ultrasound probes combined with pre-operative imaging scans to visualise soft tissue and organs during keyhole procedures, as the miniature surgical instruments used do not support internal ultrasound imaging.

For the study, published in *Light: Science & Applications*, the team of surgeons, engineers, physicists and material chemists designed and built the optical ultrasound technology to fit into existing single-use medical devices, such as a needle.

"The optical ultrasound needle is perfect for procedures where there is a small tissue target that is hard to see during keyhole surgery using current methods and missing it could have disastrous consequences," said Dr. Malcolm Finlay, study co-lead and consultant cardiologist at QMUL and Barts Heart Centre.

"We now have real-time imaging that allows us to differentiate between tissues at a remarkable depth, helping to guide the highest risk moments of these procedures. This will reduce the chances of complications occurring during routine but skilled procedures, such as ablation procedures in the heart. The technology has been designed to be completely compatible with MRI and other current methods, so it could also be used during brain or fetal surgery, or with guiding epidural needles."

The team developed the all-optical ultrasound imaging technology for use in a clinical setting over four years. They made sure it was sensitive enough to image centimetre-scale depths of tissues when moving; it fitted into the existing clinical workflow and worked inside the body.

"This is the first demonstration of all-optical ultrasound imaging in a clinically realistic environment. Using inexpensive optical fibres, we have been able to achieve high resolution imaging using needle tips under one mm. We now hope to replicate this success across a number of other clinical applications where minimally invasive surgical techniques are being used," explained study co-lead, Dr. Adrien Desjardins (Wellcome EPSRC Centre for Interventional and Surgical Sciences at UCL).

The technology uses a miniature optical fibre encased within a customised clinical needle to deliver a brief pulse of light which generates ultrasonic pulses. Reflections of these ultrasonic pulses from tissue are detected by a sensor on a second optical fibre, giving real-time ultrasound imaging to guide surgery.

One of the key innovations was the development of a black flexible material that included a mesh of carbon nanotubes enclosed within clinical grade silicone precisely applied to an optical fibre. The carbon nanotubes absorb pulsed laser light, and this absorption leads to an ultrasound wave via the photoacoustic effect.

A second innovation was the development of highly sensitive optical fibre sensors based on polymer optical microresonators for detecting the ultrasound waves. This work was undertaken in a related UCL study led by Dr. James Guggenheim (UCL Medical Physics & Biomedical Engineering), and recently published in *Nature Photonics*.

"The whole process happens extremely quickly, giving an unprecedented real-time view of soft tissue. It provides doctors with a live image with a resolution of 64 microns, which is the equivalent of only nine red blood cells, and its fantastic sensitivity allows us to readily differentiate soft tissues," said study co-author, Dr. Richard Colchester (UCL Medical Physics & Biomedical Engineering).

The team is now working towards translating the technology for clinical use in patients.

The work was kindly funded by the European Research Council, Wellcome, the Engineering and Physical Sciences Research Council and the NIHR Barts Biomedical Research Centre.

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