Abstract 1

Effect of Prenatal Diagnosis on Hospital Costs in Patients with Complete Transposition of Great Arteries

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Background: Healthcare expenditure per capita in United States in 2012 was $8,895. Prenatal diagnosis (PD) leads to better clinical outcomes but the impact on resource utilization or health care cost is unknown. We sought to compare the total hospital cost of patients with PD of complete transposition of the great arteries (d-TGA) versus those without PD.

Methods: A retrospective analysis was performed to identify all infants with a diagnosis of d-TGA born or referred to our center from July 2006 to July 2014. The total charges of initial hospitalization were obtained. Charges for all patients were converted to 2013 equivalent dollars using the Consumer Price Index (CPI) for medical care. Cost to charge ratio was used to convert the charges to costs. A direct cost comparison was performed between patients with known PD of d-TGA and those without PD. A sub-analysis was also performed for the cost of pre-hospitalization fetal diagnosis.

Results: 34 (26 without PD and 8 with PD) infants with d-TGA were identified. No statistically significant difference was present in mean weight (3.4 ± 0.53 vs 3.6 ± 0.39kg, p=0.328), gestational age (38.5 ± 1.2 vs 37.9 ± 2.6 weeks, p=0.947) and mean length of stay (28.4 ±16.4 vs 25.8 ± 7.2 days, p=0.968). 100% of infants with PD were born at our facility versus 3.8% without PD. Mean direct cost in infants without PD was $97,800 ± 45,900 vs $80,800 ± 21,100 in infants with PD. The mean transport costs were $7,300 ± 6,800 in patients without PD and accounted for the major difference in cost. The room and board cost in infants without PD accounted for a $5,000 difference in mean costs ($36,700 ± 20,700 vs $31,700 ± 11,300). Infants without PD had higher cost associated for mechanical ventilation and respiratory care ($5,400 ± 3,700 vs $4,000 ± 2,000). In a sub-analysis the cost of pre-hospitalization fetal diagnosis was <1% of total mean hospital costs.

Conclusions: In the absence of PD, the cost of caring for infants with d-TGA was 21% higher compared to infants with PD. Primary factors reducing the cost in infants with PD of d-TGA include: transport costs, room and board costs and respiratory care costs. Prenatal diagnosis of d-TGA not only improves clinical outcomes but also decreases resource utilization and health care cost.
Abstract 2

**Cardiac Computed Tomographic Angiography (CTA) as Primary Decision Making Tool for Initial Surgical Repair in Patients with Tetralogy of Fallot (TOF) and Pulmonary Atresia (PA)**

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**Background:** To demonstrate the accuracy/adequacy of Cardiac CTA in infants with TOF and PA as initial pre-operative decision-making tool.

**Methods:** Retrospective analysis of infants evaluated at our center with TOF/PA with or without Major Aorto-Pulmonary Collateral Arteries (MAPCAs) was conducted from Jan 2008 to Jan 2014. CTA was done in all 8 infants as the initial and only pre-operative study. CTA findings were compared with direct intra-operative observation for presence/size of patent ductus arteriosus (PDA), number/size of MAPCAs, anatomy & dimensions of the main and branch pulmonary arteries (PAs).

**Results:** 8 infants were identified (6 males and 2 females). Median age at diagnosis: 1 day (range 0-29 days), median birth weight: 3.1 kg (range: 2.8-3.2 kg). CTA identified 6 infants with moderate sized tortuous PDA without MAPCAs while 2 had MAPCAs without presence of PDA. 7 infants demonstrated confluent branch PAs while one had discontinuous branch PAs individually fed by the MPACAs. Confluence of the PAs ranged from 3 to 7 mm and size of the branch PAs ranged from 1.4 to 6.3 mm (Table 1). Primary cardiac correction was performed in five infants while central shunts with or without unifocalization were performed in the remaining three patients. In both patients who underwent unifocalization, all unifocalizable collaterals were identified on CTA.

**Conclusion:** CTA demonstrated 100% accuracy in identification of both clinically significant MAPCAs as well as shape and size of PDA in the respective subset of infants with TOF/PA when compared to direct intra-operative observation. CTA provided the surgeon with a 3-D road map, which was crucial to pre-operative planning. This study demonstrates the accuracy of CTA in pre-operative planning for infants with TOF/PA thus obviating the need for diagnostic cardiac catheterization, which is more expensive, more invasive, requires anesthesia and has higher radiation exposure.
Abstract 3

Ultrasound-guided Femoral Arterial Access in Pediatric Cardiac Catheterizations: Prevalence and Risk Factors for Acute Loss of Arterial Pulse - A Prospective Single Center Cohort Study

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Background: Acute loss of arterial pulse (LOP) is a known complication in children following femoral arterial (FA) access for cardiac catheterization. The prevalence of LOP requiring treatment ranges between 4% and 8%. The objectives of this study was to describe the
prevalence and identify risk factors for LOP in children who had ultrasound guided femoral arterial access (UGFAA) during cardiac catheterization.

**Methods:** A prospective study was performed including 486 cardiac catheterizations using UGFAA in children (≤18 years) over a 20 month period. Ultrasound and Doppler evaluation were performed prior to and at the end of the procedure. Treatment was initiated for the presence of thrombus or with absence of Doppler pulsations one hour post-procedure. Multivariate analysis was performed to identify risk factors.

**Results:** LOP was identified in 33 cases (6.8%) with 23 (4.7%) requiring treatment. For children ≤ 6 months the prevalence of LOP requiring treatment was 13.6%. Femoral artery diameter < 3mm was the only significant independent predictor for LOP (OR = 11.7, 95% CI: 3.9 – 24.8, P <0.001). Number of access attempts, time required for access, operator experience, sheath size, sheath exchanges, activated clotting time, hemoglobin, cardiac output, procedure length, etc., were not found to be significant factors. Those who had LOP, had a greater percentage (median 62% vs. 18%, P <0.001) decrease in vessel diameter. Femoral artery (FA) thrombus was diagnosed in 9 patients (1.8% of all cases, 27% of those with LOP).

**Conclusions:** The overall prevalence of LOP requiring treatment of 4.7% is similar to reports where UGFAA is not used. This study suggested that the mechanism of LOP was more due to spasm of the FA than thrombus formation. Femoral artery diameter < 3mm was the only independent predictor for LOP in this carefully designed prospective study.
Abstract 4

**Clinical Evaluation of a Radio-Protective Cream for the Hands of the Pediatric Interventional Cardiologist**

Kaitlin Balduf, MD; Saradha Subramanian, MD; B. Rush Waller, MD; Vijaykumar Agrawal, M.D; David Zurakowski, PhD; Andrew Kuhls-Gilcrist, PhD; Ashok Khandkar Ph.D; Shyam K Sathanandam, MD

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**Background:**

The hands of interventional cardiologists receive high doses of scatter radiation due to their proximity to the X-Ray beam. Radiation attenuating gloves have about a 26% attenuation rate, but may reduce dexterity and tactile sensation. The UltraBLOX™ is a new FDA approved X-Ray attenuating cream that can be applied to the operator’s hands for radio-protection. The aim of this study was to evaluate the effectiveness of this cream during lengthy cardiac catheterization procedures in children.

**Methods:**

2 nanoDot™ dosimeters were secured side by side on the dorsum of the operator’s (n=8) left hand close to the wrist. One dosimeter and the rest of the hand were covered with 0.2 mm layer of the cream. The other dosimeter was unshielded. Procedures were performed using 110 kVp fluoroscopy at 15 pulses/sec. Four time categories were analyzed for differences in attenuation.

**Results:**
The patients in all 4 groups were well matched for age and size. Procedural and cumulative hand radiation doses were higher with longer procedural duration. The overall percentage attenuation by the cream was 39.7% (28.6 - 51.5) and was not affected by the length of the procedure (median: 40.9% at 30 min and 41.4% at 180 min; p=0.66) or the dose of radiation. The kappa statistic for inter observer agreement for good tactile sensitivity was 0.82.

**Conclusions:**

The UltraBLOX™ provides a new option for radio-protection for the hands of interventional cardiologists without impairing tactile sensitivity. The attenuation afforded did not reduce up to 180 min.

Abstract 5

**Percutaneous closure of paravalvular leak after tricuspid valve replacement using real time 3-Dimensional echocardiography**

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**Arkansas Children’s Hospital, University of Arkansas for Medical Sciences**

**Background**

Paravalvular regurgitation affects 5–17 % of all surgically implanted prosthetic heart valves; however incidence in children is not reported. Owing to the frequent morbidity at presentation and risks of re-do surgery, percutaneous closure is preferred in adults. We report successful device closure of paravalvular leak following Tricuspid valve replacement under transesophageal echocardiographic (TEE) guidance.

**Methods and Results**

A 16-year-old female born with Truncus arteriosus and status post repair developed severe tricuspid valve regurgitation and associated exercise limitation. She underwent tricuspid valve replacement using a 33 mm St. Jude Epic valve along with right ventricle to pulmonary artery conduit replacement. She was noted to have moderate to severe tricuspid paravalvular leak associated with development of lower limb edema and dyspnea few weeks after the operation.
The procedure was done using 2D (two dimensional) and real time 3D TEE guidance. The defect was triangular, measured 10-12 mm in largest dimension and located near the perimembranous septal region medially (Figure 1). There is no dedicated device available as yet for paravalvular leak closure. Device selection is based on anatomy on available imaging modalities and available devices. A 4 Fr angled glide catheter and a 0.014” Terumo run through wire was used to cross the defect and the angled glide catheter was advanced across the defect. Another 0.018” SV5 wire (Cordis) was also inserted. A 16 mm Amplatzer vascular plug II (St Jude Medical, Inc.) was deployed using real time 3D imaging for guidance. TEE showed the device was stable with near complete occlusion and the residual insufficiency was trivial without any impingement on valve leaflets. There were no effects of impingement on atrioventricular node. The patient is asymptomatic three months post procedure.

**Conclusion**

Real time 3D imaging with TEE is useful for percutaneous closure of paravalvular leak. Figure 1:
A case series of the new Subcutaneous- ICD implants in a pediatric center

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Background

Complications of implantable cardioverter-defibrillator (ICD) therapy are often linked to transvenous lead insertion, lead failure, or infections. An entirely subcutaneous ICD system (S-ICD) avoids the need for the placement of electrodes within the heart and can provide clinical advantages especially in pediatric population. The S-ICD System – which was approved by the Food & Drug Administration (FDA) in 2012 and which gained Category 1 CPT Codes in January 2015 – was shown to be highly effective, converting more than 98 percent of heart arrhythmias that can lead to sudden death. These data are comparable to efficacy outcomes found in transvenous ICD (TV-ICD) clinical trials (95-99%). We describe the initial experience of S-ICD implants in four children in electrophysiology laboratory in Arkansas Children’s Hospital.

Methods and Results

Since approval of the Category 1 CPT Codes in January, 2015, four patients have undergone S-ICD implants at our center. (Table 1)

A left lateral incision was made over the sixth rib in the anterior axillary line for pocket formation and pulse generator placement. The subcutaneous electrodes were placed by 2-incision technique and tunneling in the 1st two cases and by a single subxiphoid incision and tunneling in the last 2 cases. Fluoroscopy was not required during the procedure. Ventricular fibrillation was induced and terminated by a 65-J shock (15-J safety margin) in all the patients. No complication occurred, and subsequent course was uneventful.

Conclusion

S-ICD is a new system for delivering lifesaving shock therapy in patients at risk of sudden cardiac death, without the need of intracardiac leads. Young patients could benefit the most from this system. The implantation can be safely performed in catheterization laboratory in children.
<table>
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<th>Patient</th>
<th>Age (y)</th>
<th>Diagnosis</th>
<th>Screening Passed</th>
<th>DFT</th>
<th>Device</th>
<th>Incision technique</th>
<th>Procedure time (min)</th>
<th>Follow up</th>
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<td>Leads I, II, III</td>
<td>65 J</td>
<td>S-ICD 145 g, (78.2 X 65.5 X 15.7 mm)</td>
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<td>92</td>
<td>6 mon</td>
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<td>17, M</td>
<td>Heart transplant with ischemic cardiomyopathy and LVEF &lt; 30%</td>
<td>Leads I, II, III</td>
<td>65 J</td>
<td>S-ICD 145 g, (78.2 X 65.5 X 15.7 mm)</td>
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<td>3</td>
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<td>Hypertrophic cardiomyopathy s/p transvenous ICD; inappropriate shocks and lead failure</td>
<td>Leads II, III</td>
<td>65 J</td>
<td>S-ICD Emblem 130 g, (69.1 X 83.1 X 12.7 mm)</td>
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<td>4</td>
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<td>S/p sudden cardiac arrest; idiopathic ventricular fibrillation</td>
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<td>S-ICD Emblem 130 g, (69.1 X 83.1 X 12.7 mm)</td>
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<td>80</td>
<td>1 mon</td>
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Table 1

Abstract 7

**First report of a successful Berlin Excor Bi-Ventricular Assist Device explantation**

Tamara Thomas, MD, Rupal Bhakta, MD, Lindsey Pumphrey, RN, Srikant Das, MD

Arkansas Children’s Hospital, University of Arkansas for Medical Sciences
Background

We report the first case of a Berlin EXCOR (Bi-Ventricular Assist Device) BiVAD explantation in a child with cardiomyopathy secondary to abnormal ventricular preexcitation.

Methods and Results

A 13 kg, 20 months old, Caucasian female, presented with fever, congestion and cardiomegaly. An electrocardiogram showed ventricular pre-excitation from a right sided accessory pathway and echocardiogram showed structurally normal heart with severely dilated left ventricle and severely diminished biventricular function (Figure1). Medical management with Milrinone, Epinephrine, and mechanical ventilation was started. An attempted ablation of the accessory pathway was unsuccessful. She was listed for heart transplant and underwent Berlin Heart EXCOR BiVAD placement (30 ml LVAD pump, 25 ml RVAD pump).

18 days post implantation, another electrophysiology study was performed with 2 catheters and patient on BiVAD support. There was no supraventricular tachycardia inducible or noted at any time of her stay. The accessory pathway was localized to right anterolateral position on the tricuspid valve annulus and successfully ablated with radio frequency energy. After ablation and loss of preexcitation the cardiac dysfunction improved. Due to recovery of heart function, a BiVAD wean protocol was initiated and she underwent a successful Bi-VAD explantation 48 days after the implant and 30 days after the successful ablation. The explantation was successfully undertaken using a modification and adaptation of the existing Berlin LVAD explantation protocol. The patient was discharged home and remains well on follow up after 15 months.

Conclusion

Ventricular preexcitation induced cardiomyopathy is rare secondary to abnormal ventricular activation, but is reversible. This is the first case report of a Berlin EXCOR BiVAD explantation in a patient with dilated cardiomyopathy, when cardiac function improved after successful ablation of a right sided accessory pathway.

Figure 1:
Transcatheter recanalization of isolated left pulmonary artery in a 2 month old with Tetralogy of Fallot

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**Background**

To describe imaging features of an isolated left pulmonary artery (LPA) and report successful recanalization by transcatheter intervention in a 2 month old with Tetralogy of Fallot (ToF).

**Methods and Results**

A previously healthy 8 weeks old male presented with a febrile illness and murmur and was diagnosed with ToF with right aortic arch. His LPA could not be visualized by echocardiogram. A computed tomography scan showed severely hypoplastic distal segment of the isolated LPA. There was a right aortic arch with a mirror image branching pattern and an ampulla at the base of left brachiocephalic artery origin. This was anticipated to be the origin of the left ductus arteriosus (DA) supplying the LPA. The DA had closed after birth and no blood flow was noted in it. The distance between the ductal ampulla and the most proximal portion of the LPA measured 22 mm in length in coronal plane.

Patient was taken to the catheterization lab to define the native LPA and for possible ductal recanalization. A wire was advanced retrograde through a catheter from right femoral artery into the base of the ductal ampulla and with gentle probing was advanced into the ductus arteriosus and distal LPA, even though there was no flow noted with injection angiograms. The catheter and wire course was convoluted due to right aortic arch. Serial balloon dilations were performed over the wire starting from 1 mm and angiograms showed recanalization of the ductus and continuity from the aortic arch to the distal LPA with establishment of blood flow. Two premounted, bare metal coronary stents (3.5 mm X 20 mm; Veriflex; Boston Scientific)) were deployed in the entire length of ductus arteriosus. Repeat cardiac catheterization and angiogram two months later showed continued patency and growth of all segments of the isolated LPA (Figure 1).

**Conclusion**

Ductus arteriosus can be recanalized in infants even when no flow is noted in the structure by angiography.
Abstract 9

TITLE: Prenatal Diagnosis of Congenital Heart Disease: A Study of Detection Rate in Southwest Virginia

AUTHORS: Catherine T Gambale, Allison Durica, Joelle Miller, Virginia Tech Carilion School of Medicine, Roanoke, VA

BACKGROUND: Identifying congenital heart disease (CHD) prior to birth optimizes care of the newborn. Few studies have examined prenatal detection rates (PDR) of CHD in the US.

METHODS: This retrospective study examined the PDR of CHD in the Roanoke, VA area over 8 years and included all newborns and non-surviving fetuses with a confirmed diagnosis of severe CHD in the Carilion Clinic Pediatric Cardiology (PC) practice between January 2007 and May 2015 (n=170). The PDR for patients born (or with fetal demise) during two time periods were compared; 2007-2011 (n=104) and 2012-2015 (n=66). The second time period followed protocol changes made in the Maternal Fetal Medicine (MFM) ultrasound laboratory with augmentation of the cardiac anatomy views to include the three vessel view. PDR was correlated with ductal dependency (DD), need for early surgical intervention (ES), prior evaluation by (MFM) or fetal echocardiogram (FE) and compared between the time periods. The PDR was compared by lesion type for the entire cohort.

RESULTS: Fetuses with CHD were more frequently referred by MFM for FE (77.8%, 94.3%, p<0.04) during the second time period with improved PDR (66.7%, 85.7%, p<0.05). No change was seen in the overall referral rate to MFM (60.6%, 53.0%) or for FE (50.5%, 56.1%). When comparing time periods, there was no significant difference in the PDR for the entire cohort, (41.3% and 50.0%), DD lesions (60.7%, 54.2 %), or ES lesions (48.7%, 55.2%). No change in the PDR was observed for patients evaluated by FE (82.7% vs 89. %).

For the entire cohort, single ventricle (SV) (73.7% vs 45.4%, p<0.02) and endocardial cushion defects (ECD)(66.7% vs 45.4%, p<0.04), were detected more frequently while coarctation of the aorta (CoA) (19.4% vs 45.4%, p<0.001) had a lower PDR. There was no significant difference in the detection rate for DD and ES lesions.

CONCLUSION: Despite improvement of PDR for patients evaluated by MFM, the overall PDR of CHD in the Roanoke remained unchanged. This underscores the importance of recognition of high-risk fetuses by community providers and improved prenatal referral. In this study CoA was less likely to be recognized while SV and ECD were detected more frequently.
Abstract 10

Clinical Evaluation of the Toshiba 3D Multi-Modality Fusion Software Application in Congenital Cardiac Intervventional Catheterizations

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University of Tennessee Health Science Center, Le Bonheur Children’s Hospital, Memphis, TN;

\textsuperscript{4}Department of Biostatistics, Harvard Medical School, Boston, MA;

\textsuperscript{5}Toshiba America Medical Systems, Tustin, CA.

\textbf{Background}: The Toshiba, 3-D Multi-Modality Fusion Roadmap (3D-MMF) is a software application that enables overlay of previously acquired 3-D image with live 2-D fluoroscopy images. 3-D data sets can be rendered from either a CT or MR scanner or 3-D rotational angiography (3DRA). The objectives of this study was to determine the feasibility of multi-vendor 3D-MMF (GE MRI, and Siemens CT), differences in procedural radiation and contrast doses between 3DRA-Fusion, MR-Fusion and CT-Fusion procedures and the diagnostic and clinical utility of each modality during congenital cardiac interventional catheterizations.
Methods: Catheterization data from matched patient groups undergoing 3DRA-Fusion, MR-Fusion and CT-Fusion were reviewed. The radiation, contrast dose, anesthesia time, fluoroscopic time were compared including what was needed to obtain the CT or MR. The quality and utility of the 3D-fusion roadmap during the procedure and clinician satisfaction were scored by the operators and 4 qualified independent observers.

Results: The 3DRA-Fusion (n=15), MR-Fusion (n=15) and CT-Fusion (n=10) groups were well matched for age (mean 9.8, 10.2 and 11.1 years; p=0.39) and size (mean BSA 1.02, 1.08 and 1.2 m²; p=0.11). Patients in the MR-Fusion group compared to the CT-Fusion and 3DRA-Fusion groups had lower indices of radiation exposure measured by fluoroscopy time (18 vs. 19.4 vs. 21.8 Minutes; p=0.04), total dose-area product (2454 vs. 5607 vs. 4101 cGy·cm², p = 0.01), and total air kerma dose (499 vs. 806 vs. 654; p = 0.01). There was also a significant reduction in contrast dose (2.7 vs. 5.9 vs. 4.9 mL/kg, p <0.001). Procedural time tended to be shorter in the MR-Fusion group (163 vs. 167 vs. 214 minutes; p <0.03) but anesthesia time was significantly longer (384 vs. 213 vs. 258 minutes; p <0.001). For clinical utility, 3DRA-Fusion had highest satisfaction scores (90%) among operators and independent observers compared to MR-Fusion (82%) and CT fusion (84%).

Conclusions: It is feasible to perform multi-vendor 3D-MMF using the new Toshiba software with good clinician satisfaction scores. MR-Fusion helps reduce procedural radiation and contrast doses during congenital cardiac interventional catheterizations.

Abstract 11

The Use of Digital Subtraction 3-D Rotational Angiography during Cardiac Catheterization in Children Less Than Two Years of Age

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Asim F Choudhri, MD; Lucas Elijovich, MD; David Zurakowski, PhD;
Andrew Kuhls-Gilchrist, PhD; Jason Johnson, MD; Shyam K Sathanandam, MD

1Department of Pediatrics, Division of Pediatric Cardiology; 2Department of Radiology,
3Division of Neurosurgery,
University of Tennessee Health Science Center, Le Bonheur Children’s Hospital, Memphis, TN;

4Department of Biostatistics, Harvard Medical School, Boston, MA;

5Toshiba America Medical Systems, Tustin, CA.

Background: Advantages of rotational angiography during cardiac catheterization include
tomographic imaging, 3D road-mapping etc. Concerns over potentially higher contrast and
radiation doses have limited its routine use in infants. We instituted a digital subtraction
3D rotational angiography (DS-3DRA) protocol for use in infants. The objective of this
study was to compare radiation and contrast doses required for obtaining DS-3DRA with
conventional digital 3DRA (DA-3DRA) in children ≤ 2 years of age.

Methods: Radiation and contrast doses required for DS-3DRA was compared with age-,
size- and diagnosis-matched historical controls that had DA-3DRA. Only children ≤ 2 years
of age were included in the study. A 1:1 control matching was performed. Those patients
that did not have matching controls were excluded from the study. The diagnostic quality
and utility of these two modalities were scored by 4 qualified independent observers.

Results: The study (n=7) and control (n=7) groups were well matched for age (mean 14 vs.
15 months; p=0.239) and size (mean BSA 0.42 vs. 0.44 m²; p=0.103). The mean dose area
product (DAP) to acquire DS-3DRA was 34% higher than DA-3DRA (128 vs. 188 cGy·cm²;
p=0.014). Similarly, the DS-3DRA air-Kerma, albeit small, was 47% higher than the DA-
3DRA air-kerma (mean = 21.7 vs. 11.4 mGy; p<0.01). However, the contrast volume to
 acquire the best diagnostic quality DS-3DRA was 44% less than what was required for DA-
3DRA (mean 1.02 vs. 1.81 mL/kg; p<0.001). The diagnostic quality and utility scores for the rotational angiography (86% vs. 84%; p=0.32), multi-planar reformation (84% vs. 88%; p=0.12), 3D reconstruction (79% vs. 86%; p=0.14), and 3D road-mapping (88% vs. 89%; p=0.36) were similar for both modalities.

**Conclusions:** Digital subtraction rotational angiography can help reduce contrast volumes required to perform 3DRA in children ≤ 2 years of age. The radiation dose for DS-3DRA, albeit small, is a little over a third higher than for DA-3DRA. The diagnostic quality and utility of DS-3DRA for infants with congenital heart diseases is equivalent to conventional 3DRA.

Abstract 12

**Growth Curves for Femoral Vein and Artery in Children Under Five Years of Age**

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1Department of Pediatrics, Division of Pediatric Cardiology; 2Department of Radiology, University of Tennessee Health Science Center, Le Bonheur Children’s Hospital, Memphis, TN; 3Department of Biostatistics, Harvard Medical School, Boston, MA;

**Background:** The femoral vein (FV) and artery (FA) are the most common vessels used for catheter access in children. However, nomograms based on the sex, race, age or size of children are not available at present. This knowledge, however, may be of fundamental importance for pediatric interventional cardiologists who use these vessels to perform complex interventions, requiring large catheter and sheath sizes. The objective of this study was to construct growth curves for FV and FA in children ≤ 5 years of age.

**Methods:** A prospective study was performed on 400 children with congenital heart diseases ≤ 5 years of age undergoing cardiac catheterization procedures over a 20 months’ period. Patients who had previous cannulation of these vessels were not included in this study. Ultrasound evaluation was performed under anesthesia just prior to obtaining access on both the right and left femoral vein and artery. The diameter and the cross sectional areas of these vessels were measured at a level just
proximal to the bifurcation of the common FA. Regression modeling was applied to derive the growth curves based on quantile polynomial regression, which yielded good fit to the data judged by R-squared and the LMS transformation method was used to determine the smoothed percentile.

**Results:** Growth curves were constructed for the diameter and CSA of the FA and FV against patient age and body surface area (BSA). Distinction for sex and race was not made secondary to the small sample size. Only the right femoral vein and artery was used for analysis. The Figure below illustrates the findings.

**Conclusions:** It is now possible to predict the normal diameter of the femoral vein and artery, and these nomograms may help with planning an interventional procedure. Future studies with larger sample size may be useful.

Abstract 13

Knowledge improvement as a result of active learning with further emphasis on subspecialty fellow involvement

Stefani Samples MD, Nirupma Sharma MD

Institutional Affiliation: Children’s Hospital of Georgia, Georgia Regents University

Contact: ssamples@gmail.com
Background: Multiple studies in recent years have demonstrated that traditional “stand and deliver” lectures are less effective in communicating information to students in a classroom setting than other active learning activities that actively engage the students in the learning process. The primary purpose of this study was to examine if medical students had an improvement in their knowledge base of a pediatric subspecialty topic following a traditional lecture with additional active learning components. A secondary aim was to demonstrate ways to engage fellows promote an attention to academia as they progress through their careers.

Methods: A new academic half day teaching session was established for 3rd year medical students on their pediatric rotation. The senior pediatric cardiology fellow gave a one-hour lecture with active learning components. The students were given pre and posttests as a part of their lecture series, and the results were examined.

Results: There was no different in pretest scores based on the students reported past experience in a pediatric cardiology clinic setting (p=0.348). The average pretest score was 79.7% (95%CI 77-82.4), and the average posttest score was 95% (95%CI 93.3-96.7). The lower the pretest score, the more improvement shown on the posttest (p<0.001). There was also a significant improvement in self-scoring by the students (p<0.001).

Conclusions: Traditional lectures with added active learning components are an effective way to teach medical students necessary information on their clinical rotations. The use of subspecialty fellows to give these lectures should be considered to encourage their continued engagement in education.

Abstract 14

DETECTION RATE OF FETAL TRICUSPID REGURGITATION IN NEW VERSUS OLD ULTRASOUND TECHNOLOGY AND ITS ASSOCIATION WITH OTHER CARDIAC ABNORMALITIES

Stefani Samples M.D., Trace Deighan B.S., Matthew Smith B.S.A., William Lutin M.D., PhD, Henry Wiles M.D.

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Contact: ssamples@gru.edu

Background: Pediatric cardiologists use several tools to assess for prenatal cardiac abnormalities including fetal echocardiography, part of which involves evaluating for tricuspid regurgitation (TR). Historically, the presence of TR has been considered a strong indicator of other fetal cardiac abnormalities; however, advancements in ultrasound technology have brought this theory into question. Predicting that TR detection is higher today due to technological advances, the aims of this study were to compare the detection rate of TR in old and new ultrasound technologies, to further
quantify detected TR by severity, and to assess the association between the severity and presence of other cardiac abnormalities.

**Methods:** 581 fetal echocardiograms were reviewed and evaluated for the presence and severity of TR as well as the presence of other cardiac abnormalities. They were divided based on ultrasound technology used and denoted as old (Philips IE33 software 4.02.13) and new (Philips IE33 software update 6.3.3.134).

**Results:** TR detection rates were higher in newer versus older technology (p=0.0118, OR 1.72). Patients with TR were also more likely to have other cardiac abnormalities, such as a pericardial effusion, restrictive ductus arteriosus, or right ventricular hypertrophy, than those without TR (p<0.0001, OR 2.6). There was no correlation between higher TR severity and the presence of other cardiac abnormalities (p=0.068).

**Conclusion:** This study demonstrated a higher detection rate of TR when using newer technology, which also correlated with the presence of cardiac abnormalities. This knowledge may aid obstetricians and cardiologists when evaluating the significance of prenatal TR.

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**Abstract 15**

**Intrapericardial NUT midline carcinoma: Unusual presentation of a rare tumor and literature review with management considerations**

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**Abstract:**

**Background:** NUT midline carcinoma is a rare but aggressive tumor that often presents at an advanced stage in midline structures. Survival rarely extends beyond 12 months from the time of diagnosis. There have been no reports of a primary cardiac presentation, and few studies have reported on the numerous treatment strategies.

**Methods:** An unusual intrapericardial presentation with myocardial invasion of a NUT midline carcinoma in a 2 year old is described with literature review and description of management considerations.

**Results:** Treatment included surgical resection and various regimens of chemotherapy including an experimental treatment with TEN-010, a bromo domain extra terminal (BET) inhibitor. Other possible treatments in these cases include radiotherapy, but no consistently successful treatment has been established thus far.
Conclusion: Given their aggressive and invasive nature, NUT midline carcinomas present a treatment dilemma. Surgical resection is indicated to reduce symptomatic mass effect whenever present. Novel therapies with BET inhibitors may be associated with potential survival benefit, but these studies are currently ongoing.

Abstract 16

NEONATAL ENTEROVIRAL MYOCARDITIS: AN OVERLOOKED COMPLICATION OF A COMMON INFECTION?

Meghann McKane MD¹, Justin Godown MD¹, Susan Sefers MLS², Debra Dodd MD¹

Affiliations: ¹Monroe Carell Jr Children’s Hospital at Vanderbilt University Medical Center Department of Pediatrics, Thomas P. Graham Jr. Division of Pediatric Cardiology; ²Molecular Infectious Disease Laboratories, Vanderbilt University Medical Center

Background: Neonatal enteroviral infections are common and can be life-threatening due to the potential for myocardial involvement. The majority of neonatal enteroviral myocarditis cases occur with preexisting or concurrent meningitis; however, the incidence of myocardial involvement in patients with enteroviral meningitis is unknown. Our study aimed to determine the frequency of cardiovascular evaluation and spectrum of cardiovascular findings in infants with enteroviral meningitis.

Methods: This was a retrospective cohort study over a 36-month period in infants (<1 year) with confirmed enteroviral meningitis. Demographic data was reviewed with the frequency and results of cardiovascular studies (electrocardiograms [ECG] and echocardiograms [ECHO]) documented.

Results: A total of 95 infants (58% male, median age 37 days) had confirmed enteroviral meningitis during the study period. Cardiovascular evaluation was performed in 16 infants; 5 underwent ECG only, 5 underwent ECHO only and 6 had both an ECG and ECHO performed. ECG abnormalities included ST segment changes (3 infants, 27%) and prominent Q waves (1 infant, 9%). Abnormal ECHO findings included wall motion abnormalities (2 infants, 18%), moderate valvar insufficiency (1 infant, 9%), and a moderate pericardial effusion that required pericardiocentesis (1 infant, 9%). A total of 4 infants had clear evidence of myocardial involvement by ECG and/or ECHO.

Conclusions: Despite most neonatal mortality associated with enteroviral infections being secondary to myocardial involvement, cardiac evaluation was not routinely performed at our institution. The incidence of myocardial involvement in our cohort was 4%; however, this is likely an underestimation given the infrequency of cardiovascular evaluation. Further studies are needed to clarify the incidence and risk factors for myocardial involvement as well as the utility of routine screening.
Abstract 17

Moving toward a better Fontan care plan: the utility of interval cardiac MRI

Neil Zaki\textsuperscript{1}, James Parks\textsuperscript{1,2}, Tim Slesnick\textsuperscript{1,2}, Michael McConnell\textsuperscript{1,2}, Matthew Oster\textsuperscript{1,2}

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\textsuperscript{2}Children’s Healthcare of Atlanta

Background: Gated cardiac MRI offers the most detailed and accurate noninvasive method of assessing cardiac anatomy, particularly in patients with complex congenital heart disease. The proposed benefits of using cMRI as a routine screening tool in the Fontan population include early recognition of asymptomatic, post-operative anatomic and physiologic changes. In 2011 we therefore instituted at our center a recommended practice of cMRI screening in patients with Fontan physiology at 3 and 8 years post-Fontan operation. The purpose of this study was to determine the impact of this standardized practice of cMRI screening on the clinical management of a Fontan population.

Methods: We retrospectively reviewed charts from our institutional Fontan database to determine which patients were eligible for cMRI under the current guidelines and who underwent imaging from November 14, 2002 to June 25, 2015. We reviewed the frequency of obtaining cMRI and number of changes in management based on the results. Statistical significance was determined using a two-tailed mid-p exact test.

Results: There were 34 out of 120 eligible patients who underwent cMRI at 3 years after Fontan. Six patients had changes in management due to 3 year cMRI findings. The most frequent changes included more frequent cMRI monitoring and cardiac catheterization for angioplasty or stenting. At 8 years post-Fontan, there were 43 out of 150 eligible patients who underwent cMRI. One patient had a change in management due to 8 year cMRI, leading to angioplasty. No patients have yet had both 3 and 8 year cMRI. P-value for changes in management is 0.03.

Conclusions: Cardiac MRI at 3 years after Fontan completion appears to play an important role in informing the management of these medically complex patients. There appears to be less value in imaging at 8 years. Future studies of the Fontan care plan should focus on increasing compliance with the recommended imaging studies, particularly at 3 years after the Fontan.

Abstract 18

Title: "Fast-track approach in patients undergoing right ventricular outflow track intervention: Feasibility study of a comprehensive valve program and review of outcomes"
The Children’s Hospital of Georgia Heart Center, Medical College of Georgia, Georgia Regents University

Objective

Introduction of fast-track concept in patients undergoing right ventricular outflow tract intervention (RVOTI) as part of the comprehensive valve program at the Children’s Hospital of Georgia Heart Center targets early intensive care unit (ICU) and hospital discharge (Hd). Outcome analysis was undertaken.

Methods

From July 2014 to June 2015 17 consecutive patients who underwent RVOTI [including pulmonary valve or conduit insertion] using beating heart cardiopulmonary bypass (CPB). Patients (1) mechanically ventilated preoperatively, and (2) less than 30 days of life were excluded. Intraoperative meticulous hemostasis, lung recruitment strategies, use of alpha-2 adrenergic receptor agonist (Dexmedetomidine), early ICU mobilization and mediastinal drain removal in the immediate perioperative period were encountered.

Results

All patients underwent intraoperative extubation. None required postoperative reintubation due to respiratory failure. Mean age at surgery was 7.1 +/- 4.2 years. Mean CPB was 47.3 +/- 24.5 minutes. There was no 30-day mortality or readmission. Early mobilization occurred within 6 hours after arrival in the ICU in 14 (83%) patients. Mediastinal drain removal occurred in 0.7 +/- 1.0 days. ICU length of stay was 0.9 +/- 1.1 days. Hd occurred in less than 48 hours in 16 (95%) patients. Age, chromosomal syndromic anomalies, number of prior sternal reentry, CPB time, preexisting pulmonary conditions did not influence outcome.

Conclusions

Fast Track strategy in patients undergoing RVOTI can be safely performed on reproducible fashion irrespective of patient’s or procedural characteristics. Intraoperative meticulous hemostasis, lung recruitment strategies, standardized quality analgesia, early ICU mobilization and mediastinal drain removal in the immediate perioperative period can facilitate this concept. Large multi-site studies might help determine future guidelines in pursuing such strategy in this subset of patients.
Prevention of Venous Thrombotic Events in Patients Less Than Six Months of Age in a Cardiovascular Intensive Care Unit

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Le Bonheur Children’s Hospital

**Background** - The annual incidence of Venous Thrombotic Events (VTEs) in children is 5.3 per 10,000 hospital admissions, and the risk for VTEs is highest in neonates. Hospitalization in a critical care unit, a diagnosis of congenital heart disease, and the presence of a central venous catheter (CVC) confer additional risk. To reduce the prevalence of VTEs in its patient population, the Cardiovascular Intensive Care Unit (CVICU) at Le Bonheur Children’s Hospital instituted several practice changes, including placement of transthoracic lines (TTLs) in post-operative patients, addition of low dose Heparin (0.5 u/ml) to maintenance IV fluids, and staff education on the VTE risk assessment tool.

**Methods** - A retrospective qualitative study was conducted to examine the CVICU VTE rates pre-and post-implementation of the practice changes. Data regarding CVL-associated VTEs in patients less than six months of age from January 2010 through June 2012 was reviewed and compared to data from July 2012 through December 2014.

**Results** - A decrease in the rate of VTEs in the CVICU was seen with implementation of TTLs, the introduction of low dose heparin (0.5u/ml), and re-education regarding the VTE risk assessment tool. The rate of thrombotic events pre-implementation of the practices was 2.44; the rate post-implementation was 0.93. Additionally, there have been no thrombotic events since July 2014.

**Conclusion** - VTEs pose a significant risk to patients in Pediatric Cardiovascular Intensive Care Units. Successful implementation of prevention strategies will effectively reduce VTE risk in this patient population. Though presence of a CVC is the strongest predictor of VTE development, central venous access is a necessity in post-operative cardiac patients.
Prenatally Diagnosed Congenital Ventricular Outpouchings: An Institutional Experience and Review of the Literature
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1Thomas P. Graham Jr. Division of Pediatric Cardiology at Monroe Carell Jr. Children’s Hospital at Vanderbilt; 2Vanderbilt University School of Medicine, Nashville, TN

Background
Congenital ventricular outpouchings (CVOs) are a rare form of congenital heart disease and as such, the ability to determine prognosis and clinical course has proven difficult. With advances in fetal imaging, an increasing number are diagnosed prenatally. Compared to postnatally diagnosed CVOs, those diagnosed prenatally may represent a unique subgroup with increased morbidity and mortality. We aimed to provide additional insight into the prognosis and clinical course associated with prenatally diagnosed CVOs to aid with prenatal counseling and postnatal management.

Methods
A comprehensive literature review was performed of all reported cases of prenatally diagnosed CVOs, including three cases from our institution. Data extracted from the review were analyzed. Multivariate logistic regression was performed to identify factors that increase the odds of morbidity or mortality.

Results
Eighty-six cases were analyzed. Aneurysms and diverticula, specific subtypes of CVOs, occurred with similar frequency (55% vs. 45%). Aneurysms were associated with the left ventricle (LV), whereas diverticula were associated with the right ventricle (RV), (p<0.001). A pericardial effusion was diagnosed in 44%, and often associated with diverticula, (p=0.035). Diverticula increased the odds of an effusion roughly three-fold (OR 3.4, 95%CI 1.2 – 9.9). Over a median follow up of 12 months, 43% remained asymptomatic and another 13% had CVO regression or resolution; however prenatally diagnosed CVOs were associated with a 24% mortality rate, with 19/21 deaths occurring prenatally. Factors that increase the odds of mortality include hydrops fetalis (OR 8.7, 95%CI 2.0 – 37.1), a LV location (OR 15.6, 95%CI 2.2 – 108.4) and an earlier gestational age at diagnosis. The odds of mortality decrease 20% with each week increase in gestational age (OR 0.8, 95%CI 0.7 – 0.9). The subtype of CVO did not influence the odds of mortality.

Conclusions
Prenatally diagnosed CVOs represent a unique subgroup with relatively high intrauterine mortality. Serial follow up should be performed, especially in the prenatal period and during the first year, as adverse outcomes or need for interventions are likely.
Objective: To educate pediatric CICU nurses on how to effectively care for adults, especially those with congenital heart defects, as well as improve order sets in our unit, and to meet the standards of adult cardiac surgical intensive care patients.

Background:

The Children’s National CICU cares for a variety of patients in the perioperative stages of cardiac surgery, patients requiring ECMO, and patients with heart failure (either with congenital heart defects and acquired heart disease). The age groups vary as well. 2014 data showed that 5% of patients in the CICU were between 15 and 18 years old and 6% were over 18 years old compared to 37% of the patients who were between 0-6 months. RNs caring for the adult population voiced concern over a perceived knowledge deficit when caring for older patients. A group of bedside RNs formed a task force to investigate the care of adults in the CICU at Children’s National.

METHODS:

52 of 86 Registered Nurses completed a survey to assess their knowledge gap and prior experience taking care of adults in a Cardiac Intensive Care Unit which included a self-evaluation of current practice. We reviewed the Institute of Health Care Improvement (IHI) national guidelines, intensive care protocols from several cardiac ICU’s, and completed a literature review from PubMed.

RESULTS:

The survey results revealed the following:

- 58% of those surveyed did not feel properly prepared to care for adults
- 92% of those surveyed thought it was important to learn about adult care topics
- Over 50% of those surveyed identified the following as barriers: physician experience, written orders, nursing knowledge, equipment.
- Between 52% and 77% of those surveyed desired education on the following topics: sedation, medication dosing, equipment, delirium, activities of daily living (ADLs) and emergencies/codes.

CONCLUSION:
The survey results revealed a need for further education about the care of adults in the Children’s National CICU. The group is developing an education opportunity for the nursing staff focused on the areas of need identified in the survey and the literature review. The group plans on performing another survey after the education is delivered. The group plans on collaborating with the medical team to update the order sets in relation to the care of adults in the CICU.

Abstract 22

Antegrade Cerebral Perfusion at 25°C for Arch Reconstruction in Newborns and Children Preserves Perioperative Cerebral Oxygenation and Serum Creatinine

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¹ Division of Cardiothoracic Surgery, The Children’s Heart Center, The University of Mississippi Medical Center, Jackson, Mississippi
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³ Division of Pediatric Anesthesiology, The Children’s Heart Center, The University of Mississippi Medical Center, Jackson, Mississippi

Background: Antegrade cerebral perfusion (ACP) is used typically with deep hypothermia for cerebral protection during aortic arch surgery. Little data exist on the use of ACP at tepid temperatures in a pediatric population. Here we report the impact of ACP at 25°C on cerebral oxygenation and serum creatinine for newborns and children undergoing arch reconstruction.

Methods: Between 2010 and 2014, 61 newborns and children (< 5 years old) underwent aortic arch reconstruction using moderate hypothermia (25.0±0.9°C) with ACP and a pH-stat strategy. These included 44% Norwood-type operations, 30% isolated arch reconstructions, and 26% arch reconstructions with other major procedures. Median patient age at surgery was 9 days (range 3 days-4.7 years). Cerebral oxygenation (NIRS) was monitored continuously intra- and postoperatively. Serum creatinine was monitored daily.

Results: Median cardiopulmonary bypass and cross clamp times were 181 minutes (range 82-652) and 72 minutes (range 10-364), respectively. ACP was performed at a mean flow rate of 46±6 ml/min/kg for a median of 48 minutes (range 10-123 minutes). The postoperative outcomes are detailed in Table 1 below. Cerebral and somatic NIRS were preserved intraoperatively and remained at baseline postoperatively during the first 120 hours. Peak postoperative serum creatinine levels averaged 0.7±0.3 mg/dl for all patients. No patient required hemodialysis.

Table 1. Postoperative outcomes on N = 61 newborns and children

<table>
<thead>
<tr>
<th>Postoperative outcome</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge mortality, N</td>
<td>4 (6.6%)</td>
</tr>
<tr>
<td>Need for ECMO, N</td>
<td>6 (9.8%)</td>
</tr>
<tr>
<td>Median length of hospital/ICU stay, days</td>
<td>16 (range 4-104)/9 (range 1-104)</td>
</tr>
<tr>
<td>Use of temporary peritoneal dialysis, N</td>
<td>2 (3.3%)</td>
</tr>
<tr>
<td>Seizures, N</td>
<td>3 (4.9%)</td>
</tr>
<tr>
<td>Neurologic deficit or Stroke, %</td>
<td>0</td>
</tr>
</tbody>
</table>
Conclusions: ACP at 25°C preserves perioperative cerebral oxygenation and serum creatinine for newborns and children undergoing arch reconstruction. Early outcomes are encouraging. Additional study is needed to assess the impact on late outcomes.

Abstract 23

Tricuspid Annular Plane Systolic Excursion as a Marker of Right Ventricular Dysfunction in Pediatric Patients with Dilated Cardiomyopathy

Ericka S. McLaughlin, DO,1,2 Senthil Ramamurthy, MS,2 Curtis Travers, MPH,1 William L. Border, MBChB, MPH,1,2 Shriprasad Deshpande MBBS, MS,1,2 Ritu Sachdeva MBBS1,2

1Emory University School of Medicine and 2Children’s Healthcare of Atlanta Sibley Heart Center Cardiology, Atlanta, GA

Background:

Right ventricular systolic dysfunction (RVSD) is a predictor of outcomes in dilated cardiomyopathy (DCM) in adults, but little is known in children. Tricuspid annular plane systolic excursion (TAPSE) has emerged as a reliable tool to assess RVSD. We sought to determine the prevalence and prognostic significance of RVSD using TAPSE in children with DCM.

Methods:

Records of patients < 18 years followed with DCM from 8/2006 to 8/2013 were reviewed. The first echocardiogram at time of diagnosis was analyzed to obtain left ventricular ejection fraction (LVEF) and 2-D TAPSE. RVSD was defined as TAPSE age-based z-score < -2. A composite primary end-point including death, assist device or transplantation was correlated with LVEF and TAPSE.

Results:

Study population included 71 patients, with RVSD in 61 (86%). During a median follow-up of 757 days (IQR 51, 2233), the primary end-points were reached in 56%. A comparison of patient characteristics, echocardiographic measures and outcomes in those with TAPSE z-score ≤ -2 and > -2 is shown in Table 1. There was a trend towards higher LVEF in patients without RVSD (p = 0.06). TAPSE z-score ≤ -2 did not have a significant correlation with the composite primary end-point [adjusted OR 1.34 (95% CI: 0.29-6.71), p = 0.711]. Kaplan-Meier analysis showed that the event free survival was similar in the two groups based on TAPSE z-scores, but significantly lower in those with LVEF < 30%, Figures 1a-b.

Conclusion:
Children with DCM have a high prevalence of RVSD. While LVEF influenced the outcomes, TAPSE did not in this set of patients. Further studies with a larger number of patients may be helpful in understanding the influence of RVSD in children with DCM.

**Table 1:** Comparison of patient characteristics, echocardiographic measures and outcomes in patients with dilated cardiomyopathy with and without right ventricular dysfunction.
<table>
<thead>
<tr>
<th>Outcome</th>
<th>TAPSE Z-score, median (IQR)</th>
<th>LVEF, median (IQR)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death, n (%)</td>
<td>8 (13.1%)</td>
<td>0 (0.0%)</td>
<td>0.590</td>
</tr>
<tr>
<td>Transplant, n (%)</td>
<td>19 (31.2%)</td>
<td>4 (40.0%)</td>
<td>0.718</td>
</tr>
<tr>
<td>Assist device, n (%)</td>
<td>9 (14.8%)</td>
<td>0 (0.0%)</td>
<td>0.341</td>
</tr>
<tr>
<td>Death, Transplant, or Assist device, n (%)</td>
<td>36 (59.0%)</td>
<td>4 (40.0%)</td>
<td>0.315</td>
</tr>
<tr>
<td>Time to any primary end-point (days), median (IQR)</td>
<td>433 (51, 2233)</td>
<td>1374 (55, 1971)</td>
<td>0.704</td>
</tr>
</tbody>
</table>

**Figure 1:** Kaplan-Meier analysis of event free survival for TAPSE z-scores (a) and LVEF (b).
Abstract 24

Implementation of a Resuscitation Action Plan aimed to reduce morbidities and mortalities from Cardiac Arrest and Adverse Events while on Extracorporeal Membrane Oxygenation

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2Section of Pediatric Cardiac Critical Care, University of Alabama at Birmingham,
3Department of ECMO Services, Children’s of Alabama

Background:
Early recognition of individual patients at high risk for cardiac arrest may allow for proactive preventive measures and/or a rapid coordinated response in case of clinical deterioration with the potential to reduce morbidity and mortality. We started a Quality Improvement project to
identify patients at high risk for cardiac arrest with the goal of decreasing response times and improving outcomes. This lead to development of a Resuscitation Action Plan, (RAP) sheet and RAP rounds.

Methods:
All arrests the from previous year were reviewed to create inclusion criteria for RAP: Single ventricle physiology before or after stage one palliation, neonates with restrictive atrial septum (with single ventricle or d-transposition), neonates on postoperative days 0 and 1, open sternum, high inotropic /vasopressor support, recent prior arrest, new onset cardiomyopathy/myocarditis on inotropic support, arrhythmia requiring anti-arrhythmic medication(s), history of difficult airway or upper airway obstruction, ECMO patients up to 48 hours post-decannulation, pulmonary hypertension and severe lung disease.

RAP sheet includes: patient specific risk factors for arrest, pre-arrest warning signs and notification parameters, prevention measures (pre-suctioning sedation, no noxious stimuli, etc), imperative patient specific medications / equipment to be available at bedside, cardiac arrest crucial patient specific first steps, ECPR role assignments during arrest, review of access and ECMO cannulation (mode, cannulae size/location). It is the perfusionist’s responsibility to round, and determine cannulae required for the body surface area as well as desired flow rate and document it on the RAP sheet. For patients on ECMO, RAP sheet includes ECMO specific emergency protocols (air in circuit, mechanical failure, cannula dislodgement, ECPR etc.)

RAP sheets are posted at bedside with RAP magnet visual alerts on doorway and locked bedside medication cart which houses RAP medications. Multidisciplinary RAP rounds are done at bedside every shift to review the RAP sheet. Multidisciplinary simulations are periodically practiced to -enact these emergency situations in our ECMO simulation lab.

Discussion:
It is our hypothesis that a proactive discussion of potential ECMO candidates, reviewing roles and responsibilities during emergencies will increase knowledge, confidence and competency in dealing emergent situations. In the future, we plan to collect data that will hopefully reflect improvements in prevention, response, and knowledge of roles during a potential arrest or ECPR and a decrease in response times.

Abstract 25

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Authors: A. Merritt, MSN, RN, CCRN, RN-BC; A. Harlow, BSN, RN, CCRN; J. Fortkiewicz, MSN, RN, CCRN, CPN
BACKGROUND

The Joint Commission (TJC) requires healthcare organizations providing anticoagulant therapy to have a process in place to reduce the risk of anticoagulant-associated patient harm. Heparin has many uses in a Cardiac Intensive Care unit for prevention of clot formation. Heparin can be used to prevent clots in mechanical valves, central venous lines, shunts, and for general prevention of clot formation. Patients receiving anticoagulants should receive individualized care through a defined process that includes standardized ordering, dispensing, administration, monitoring, and education.

INCLUSION AND EXCLUSION

Inclusion:

- Anticoagulation for thromboembolism
- Bridging anticoagulation in patients at high risk for thromboembolism

Exclusion:

- Extracorporeal Membrane Oxygenation (ECMO)
- Cardiopulmonary Bypass
- Ventricular Assist Device
- Cardiac catheterization
- Hemodialysis or hemofiltration
- Extracorporeal photopheresis (ECP)

METHODS

The Cardiac ICU at Children’s National uses a standardized algorithm to determine adequate anticoagulation for our patients. When utilizing our guideline, the unfractionated heparin level (UFH) is used in most cases because it is most direct measurement of the drug level in the bloodstream. The RN must be aware that a PTT is an indirect measure of anticoagulation because it can be affected by factors other than heparin. Therefore, the PTT can be elevated due to factors other than heparin’s anticoagulant effect.
RESULTS
The decision tree begins before you administer the first heparin bolus to determine the patient’s underlying anticoagulation. The next steps are to determine if we are utilizing a PTT algorithm or UFH algorithm to monitor the patient. Once the decision has been made, then both lab values are followed throughout the course of anticoagulation to evaluate if the patient’s anticoagulation status or need for heparin have changed. The algorithm is standardized for all patients with our hematology department because an important resource of information. By utilizing this algorithm, the nurse is given the autonomy to freely manage the patient’s heparin dosing, lab values, and overall anticoagulation with the help of the medical team.

CONCLUSION
Managing patients who are anticoagulated is a science. Children’s National will continue to monitor these patients using multifactorial clinical signs and lab values in order to maintain proper anticoagulation.

FIGURES

<table>
<thead>
<tr>
<th>UFH level (Units/mL)</th>
<th>Bolus (Units/kg)</th>
<th>Hold (Minutes)</th>
<th>Rate change</th>
<th>Repeat PTT AND UFH level</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.1</td>
<td>50 (discuss with provider before giving)</td>
<td>0</td>
<td>Increase 10%</td>
<td>4 hours</td>
</tr>
<tr>
<td>0.1-0.34</td>
<td>0</td>
<td>0</td>
<td>Increase 10%</td>
<td>4 hours</td>
</tr>
<tr>
<td>0.35-0.7 (Target therapeutic range)</td>
<td>0</td>
<td>0</td>
<td>No change</td>
<td>Repeat in 4 hours x 1. If therapeutic again, then check daily</td>
</tr>
<tr>
<td>0.71-0.89</td>
<td>0</td>
<td>0</td>
<td>Decrease 10%</td>
<td>4 hours</td>
</tr>
<tr>
<td>0.9-1.2</td>
<td>0</td>
<td>30</td>
<td>Decrease 10%</td>
<td>4 hours</td>
</tr>
<tr>
<td>&gt;1.2</td>
<td>0</td>
<td>60</td>
<td>Decrease 15%</td>
<td>4 hours</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PTT (Seconds)</th>
<th>Bolus (Units/kg)</th>
<th>Hold (Minutes)</th>
<th>Rate change</th>
<th>Repeat PTT AND UFH level</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50</td>
<td>50 (discuss with provider before giving)</td>
<td>0</td>
<td>Increase 10%</td>
<td>4 hours</td>
</tr>
<tr>
<td>50-59</td>
<td>0</td>
<td>0</td>
<td>Increase 10%</td>
<td>4 hours</td>
</tr>
<tr>
<td>60-85 (Target therapeutic range)</td>
<td>0</td>
<td>0</td>
<td>No change</td>
<td>Repeat in 4 hours x 1. If therapeutic again, then check daily</td>
</tr>
<tr>
<td>86-95</td>
<td>0</td>
<td>0</td>
<td>Decrease 10%</td>
<td>4 hours</td>
</tr>
<tr>
<td>96-120</td>
<td>0</td>
<td>30</td>
<td>Decrease 10%</td>
<td>4 hours</td>
</tr>
<tr>
<td>&gt;120</td>
<td>0</td>
<td>60</td>
<td>Decrease 15%</td>
<td>4 hours</td>
</tr>
</tbody>
</table>
Heparin Infusion Algorithm

**Considerations:**
- Once initial decision is made to follow PTT OR UFH nomogram, titration is based on chosen nomogram. DO NOT CHANGE nomograms without a hematology consult.
- Consult hematology if titrating with UFH and PTT becomes elevated ≥120.
- Send PTT and UFH level at each lab collection, but titration of infusion is made based on chosen nomogram.
- Consider recent heparin exposure when interpreting lab values (ex: post-bypass patients), pre-op labs may be more useful with this population.

**Diagram:**
- **Send Baseline PTT & ATIII prior to starting infusion** (Consider pre-op labs for post bypass patients)
- **Bolus Heparin if indicated and start drip**
- **Repeat PTT <120**
- **PTT ≥ 120**
  - **DO NOT CHANGE DRIP RATE & IMMEDIATELY RESEND PTT & UFH LEVEL**
- **Repeat PTT ≥ 120 & UFH ≥ 0.7**
  - **Repeat PTT ≥ 120 & UFH < 0.7**
- **LIP order heparin titration per UFH nomogram & consult Hematology**

**Legend:**
- **LIP** = Low Initial Patient
- **PTT** = Partial Thromboplastin Time
- **UFH** = Unfractionated Heparin
Abstract 26

“How To Do It”: Hybrid Stent Placement for Pulmonary Vein Stenosis

Shell, Kathryn J, B.S. 1
Ebeid, Makram, M.D. 1,2
Salazar, Jorge D, M.D. 1,3
Dodge-Khatami, Ali, M.D., PhD 1,3
Batlivala, Sarosh P, M.D. 1,2

1 University of Mississippi Medical Center
School of Medicine

2 Division of Pediatric Cardiology
Batson Children’s Hospital

3 Division of Pediatric and Congenital Heart Surgery
Batson Children’s Hospital

Background

Pulmonary vein stenosis (PVS) is an often progressive and severe form of congenital heart disease (CHD). PVS can occur in isolation or in association with other forms of CHD. Diffuse PVS has a high incidence of morbidity and is often fatal without lung transplantation. The acute success of surgical and percutaneous angioplasty is good. However, restenosis is common and often rapid, with many patients requiring multiple surgical and percutaneous interventions. In this setting, we propose that intraoperative pulmonary vein stenting—“hybrid stent placement” (HSP)—may be a superior approach for select patients.

Methods

We performed HSP on three patients diagnosed with PVS between May 2010 and June 2014. One patient had was undergoing a cardiac operation for an additional lesion; the other two patients had severe PVS that recurred despite multiple transcatheater interventions. No strict age or weight criteria were defined, although all patients were 12 months or older. Patient 1 had atresia of the RUPV and severe stenosis of both left veins; stents were placed in both left veins. Patient 2 had isolated, significant LLPV stenosis. Patient 3 had single ventricle heart disease and RUPV atresia with stenosis of both left sided veins. She underwent HSP in the LLPV. EV3 IntraStent LD Max and EV3 Visi-Pro stents were used. Stents were hand mounted by the interventional cardiologists and placed directly into the vein, without a sheath, under direct vision by the surgeon through an atriotomy. Stents were not stitched to the vein wall. All patients received aspirin and/or clopidogrel after the operation.
Results

There was no perioperative mortality and no other major complications defined as stent migration, stented vessel thrombosis, or vessel perforation. All patients have undergone catheterization after HSP. In all cases, the initial catheterization was secondary to significant in-stent restenosis, while the final catheterizations were performed to increase stent diameter. The patients have undergone a median of 4 catheterizations post-HSP. Most recent catheterizations have dilated the stents to at least 7mm. Most recent echocardiogram demonstrate: patient 1, obtained 30 months after HSP, shows no turbulence through the stents with mean gradients of 3 mm Hg; patient 2, 39 months post-HSP, demonstrates minimal turbulence through the stent and no RV hypertension. Patient 3 had multiple admissions for respiratory infections and died 22 months after HSP.

Conclusion

Hybrid stent placement using larger stents for PVS avoids numerous issues with smaller stents. This approach is reliant upon a strong, ongoing collaborative relationship between congenital surgeons and interventional pediatric cardiologists, given the complexity of treating PVS.

Abstract 27

Utility And Cost Effectiveness Of Abdominal Ultrasound For Surveillance In Pediatric Heart Transplant Patients

Authors : Carrie Ciccotello¹, Shriprasad Deshpande MD MS²

¹Emory University. ²Children’s Healthcare of Atlanta, Emory University School of Medicine, Division of Pediatric Cardiology, Atlanta, Georgia

Background:

Hepatobiliary morbidities are common post solid organ transplantation. These include cholangitis, cholelithiasis, congestive hepatopathy as well as hepatitis. Specifically, the incidence of cholelithiasis in the pediatric heart transplant population has been reported to be variable between 3.2% to as high as 40%, compared to less than 1% in the general pediatric population. Proposed mechanisms have included chronic exposure to steroids, use of cyclosporine as well as dyslipidemia and obesity. At our center, we perform routine surveillance abdominal ultrasound (US) to assess for hepatobiliary pathologies in our pediatric heart transplantation patients. However, in the current era of changing immunotherapy, the incidence of gallstones as well as the utility and benefit of US is not established. The goal of this
proposed study is to inform us of the incidence of cholelithiasis in a large cohort of pediatric heart transplant population patients, assess risk factors and finally to assess the utility and cost-effectiveness of routine surveillance abdominal US.

**Methods**: Retrospective analysis of prospectively collected data on heart transplant patients between 1986 - 2015.

**Results**: 344 patients underwent heart transplantation during the study period. Age range was 0-21 years, with mean of 5.9 years. 1068 total screening US were performed which resulted in diagnosis of gallstones (single or multiple) in 20 patients (incidence of 5.8%) resulting in 1.87 positive US per 100 performed. Out of the 20, only 5 were symptomatic with abdominal pain as the primary symptom. A total of 9 patients underwent cholecystectomy (5 symptomatic + 4 asymptomatic but with multiple stones and or biliary obstruction). There were no procedural complications. Rest of the patients (11/20) did not receive any intervention. None of the symptomatic patients required ICU admission prior to procedure and did not have related long term morbidity.

There was no difference between the patients that developed gallstones compared to those who did not. 55% were managed with tacrolimus and 25% were on chronic steroids. This distribution was no different than the larger group. Similarly degree of dyslipidemia or glycemic control was no different.

**Conclusion**:

In one of the largest study to date of 1068 screen US, we found a very low positive hit rate for the screening abdominal US (1.87 per 100 US). Although, the incidence of gallstones was higher than general population (5% v/s estimated 1%), the overall morbidity was low with no added mortality burden. There were no risk factors that statistically predicted occurrence of gallstones.

A strategy of screening only the symptomatic patients may be more cost-effective and efficient with added morbidity or mortality burden based on our data.

Abstract 28

**Utilization and Utility of Cardiac Magnetic Resonance Imaging in Pediatric Myocarditis**

Alice Hales MD¹, Nina Hirsch BS²,³, Shriprasad Deshpande MD, MS¹

¹Department of Pediatrics, Division of Cardiology, Children's Healthcare of Atlanta, Emory University School of Medicine, ²Philadelphia College of Osteopathic Medicine-Georgia Campus, ³Rollins School of Public Health, Emory University, ³

**Background**: Myocarditis is an important cause of morbidity and mortality in children. It is estimated that 12% of sudden cardiac death cases in children are attributable to acute
myocarditis. Patients surviving the acute phase may develop chronic heart failure and dilated cardiomyopathy. The diagnosis of myocarditis remains mainly clinical. The role of MRI is evolving, however, with extremely limited data in pediatrics. Goal of this study was to assess the utilization cardiac magnetic resonance imaging (CMR), and the characteristics of patients who received imaging, as well as the predictive capacity of CMR findings.

Method: Baseline CMR results from a subcohort (n=20) of patients from a retrospective cohort of patients admitted to a pediatric hospital with the diagnosis of myocarditis (n=44) were evaluated. Medical records were used to obtain demographic data as well as baseline, discharge, and 1 year follow up clinical information. Univariate analysis was performed to identify most common factors of CMR use. Multivariate model selection and regression analysis was used to build a predictive model.

Results: Patients who underwent CMR were older (median 11.1 vs 15.6, p=0.004), had shorter hospital length of stay (median 4 vs 12.5 days, p=0.004) compared to the rest of the cohort. Patients who underwent CMR had overall less severe illness at presentation as evidenced by higher LVEF by echocardiography, lower peak BNP, were less likely to require advance support with inotropes, antiarrhythmics, or ventilator, and were less likely to have an outcome of cardiac death. Patients who underwent CMR were no more likely to receive therapy with IVIG. In patients who underwent CMR, the most common finding was increased T2 signal intensity (n=10) or late gadolinium enhancement (n=10).

CMR findings did not predict worse outcome alone. In a multivariate model, lower LVEF by echocardiography, higher peak CRP, and ventilator requirement were identified as predictors of cardiac death in the short term (p<0.05). Predictors of requiring heart failure medication at 1 year follow up included lower LVEF at presentation, and requirement of inotropes, ECMO, or anti-arrhythmics at presentation.

Conclusion: CMR is a mainstay diagnostic modality in acute heart failure cases when the cause is unclear. While CMR results may help the healthcare team narrow the potential etiology, it does not appear to change their likelihood of administering IVIG, and does not predict worse outcome alone. Future research should evaluate clinical decision making and the cost benefit analysis of CMR in the diagnosis of pediatric viral myocarditis.

Table 1.

<table>
<thead>
<tr>
<th>DEMOGRAPHICS</th>
<th>Patients who did NOT have CMR (n = 24)</th>
<th>Patients who had CMR (n = 20)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender, male, N=44</td>
<td>10 (47.7%)</td>
<td>17 (85.0%)</td>
<td>0.0033</td>
</tr>
<tr>
<td>Age, yr, N=44</td>
<td>11.1 (2.2 – 14.5)</td>
<td>15.6 (14.4 – 16.5)</td>
<td>0.0041</td>
</tr>
<tr>
<td>Weight, kg, N=43</td>
<td>46.5 (12.2 – 75.5)</td>
<td>70.9 (53.3 – 85.7)</td>
<td>0.0074</td>
</tr>
<tr>
<td>Race, N=44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>5 (20.8%)</td>
<td>7 (35.0%)</td>
<td>0.3561</td>
</tr>
<tr>
<td>African-American</td>
<td>12 (50.0%)</td>
<td>12 (60.0%)</td>
<td></td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>4 (16.7%)</td>
<td>1 (5.0%)</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-----------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>2 (8.3%)</td>
<td>0 (0.0%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1 (4.2%)</td>
<td>0 (0.0%)</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Insurance, N=43</th>
<th>14 (58.3%)</th>
<th>13 (68.4%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicaid</td>
<td>7 (29.2%)</td>
<td>6 (31.6%)</td>
</tr>
<tr>
<td>Private</td>
<td>1 (4.2%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Other Government</td>
<td>2 (8.3%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Not Known</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>SEVERITY OF ILLNESS</th>
<th>Length of hospital stay, N=44</th>
<th>12.5 (6.5 – 27.5)</th>
<th>4.0 (3.0 – 5.5)</th>
<th>0.0041</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echo LV ejection fraction on admission, N=43</td>
<td>28.6 (18.1 – 45.7)</td>
<td>56.8 (45.2 – 63.9)</td>
<td>0.0006</td>
<td></td>
</tr>
<tr>
<td>Peak BNP, N=38</td>
<td>2690.0 (1380 – 4890.0)</td>
<td>136.0 (49.3 – 475.0)</td>
<td>0.0005</td>
<td></td>
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<tr>
<td>Peak troponin, N=34</td>
<td>3.8 (0.1 – 16.0)</td>
<td>13.9 (6.7 – 29.6)</td>
<td>0.0895</td>
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<tr>
<td>Peak CRP, N=39</td>
<td>5.5 (2.2 – 19.2)</td>
<td>2.7 (1.0 – 7.0)</td>
<td>0.1689</td>
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</tr>
<tr>
<td>Abnormal EKG, N=44</td>
<td>17 (70.8%)</td>
<td>15 (75.0%)</td>
<td>0.7573</td>
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</tr>
<tr>
<td>Required inotropes, N=44</td>
<td>22 (91.7%)</td>
<td>8 (40.0%)</td>
<td>0.0002</td>
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<tr>
<td>Required VAD, N=44</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>1.0000</td>
<td></td>
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<tr>
<td>Required ECMO, N=44</td>
<td>7 (29.2%)</td>
<td>1 (5.0%)</td>
<td>0.0544</td>
<td></td>
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<tr>
<td>Required antiarrhythmics, N=44</td>
<td>19 (79.2%)</td>
<td>8 (40.0%)</td>
<td>0.0079</td>
<td></td>
</tr>
<tr>
<td>Required ventilator, N=44</td>
<td>12 (50.0%)</td>
<td>2 (10.0%)</td>
<td>0.0046</td>
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</table>

<table>
<thead>
<tr>
<th>THERAPY</th>
<th>Received IVIG, N=44</th>
<th>19 (79.2%)</th>
<th>14 (70.0%)</th>
<th>0.4844</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Received steroids, N=44</td>
<td>13 (54.2%)</td>
<td>5 (25.0%)</td>
<td>0.0501</td>
</tr>
<tr>
<td></td>
<td>Received antivirals, N=44</td>
<td>4 (16.7%)</td>
<td>0 (0.0%)</td>
<td>0.1140</td>
</tr>
<tr>
<td></td>
<td>Received other immunosuppressants, N=44</td>
<td>4 (16.7%)</td>
<td>0 (0.0%)</td>
<td>0.1140</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OUTCOMES</th>
<th>Cardiac death (death or heart transplant), N=43</th>
<th>6 (26.1%)</th>
<th>0 (0.0%)</th>
<th>0.0229</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discharged on heart failure medications, N=43</td>
<td>13 (56.5%)</td>
<td>13 (65.0%)</td>
<td>0.5706</td>
</tr>
<tr>
<td></td>
<td>Readmitted within 1 year, N=41</td>
<td>5 (20.8%)</td>
<td>2 (11.8%)</td>
<td>0.6786</td>
</tr>
<tr>
<td></td>
<td>Outcome at 1 year (cardiac death, alive +heart failure meds, alive no meds, N=35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alive on HF meds</td>
<td>10 (50.0%)</td>
<td>5 (33.3%)</td>
<td>0.4465</td>
</tr>
<tr>
<td></td>
<td>No HF meds</td>
<td>4 (20.0%)</td>
<td>5 (33.3%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Death</td>
<td>2 (10.0%)</td>
<td>0 (0.0%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lost to follow-up</td>
<td>4 (20.0%)</td>
<td>5 (33.3%)</td>
<td></td>
</tr>
</tbody>
</table>
OUTCOME OF CONGENITAL HEART REPAIR IN PREMATURE INFANTS: A COMPARISON OF EARLY REPAIR VERSUS DELAYED REPAIR


#Meharry Medical College, School of Medicine, Nashville, TN
* Vanderbilt University Medical Center, Nashville, TN

Introduction
The appropriate management of the small, premature infant with complex congenital heart disease (CHD) requiring neonatal surgical intervention is unclear.

Methods
A retrospective chart review was performed on infants less than 2 kg with CHD born between 2005 and 2013, and requiring neonatal surgical intervention. Infants were divided into 2 groups: a surgical group (early surgical intervention) and a medical group (delayed surgical intervention after a period of medical management). Hospital days, ventilator days and gestational age were analyzed with a parametric t-test. Major complications (ECMO, CPR, stroke, NEC, bacteremia, pneumonia, respiratory failure, sepsis, thrombosis, effusions, arrhythmia) and minor complications (transfusion, GE reflux, feeding intolerance, apnea, UTI) were compared using regression analysis and chi-squared.

Results
Eighty-three infants with CHD weighing less than 2 kg were identified. Seventeen were excluded due to non-viability or immediate medical instability requiring intervention. Twenty-four patients were excluded due to conditions which did not warrant an immediate decision between early and delayed repair. Of the 42 remaining patients, 15 were in the surgical group and 27 were in the medical group. There was no significant difference in overall incidence of major complications or minor complications, and no difference within the individual complications themselves. There was no difference between the medical and surgical groups in length of stay (81 vs. 53 days, p=0.10) or mortality (37% vs. 27%, p=0.5). There was a significant difference in gestational age at presentation between the medical and surgical groups (31 vs. 34 weeks, p <0.01), birthweight (1527 gm vs. 1725 gm, p=0.01) and ventilator days (43 vs.13, p=0.02).

Discussion
We found no statistically significant difference in length of stay, complications, or survival between infants with CHD treated with initial medical management and those treated with early surgical intervention. A possible institutional bias was discovered, with a preference for medical management of the smaller infants over early surgical intervention. It is possible that this bias plays a role in the increased number of ventilator days seen in the medical group.
Abstract 30

Can We Predict Recovery of Conduction in Postoperative Complete Atrioventricular Block after Surgical Repair of Congenital Heart Disease?

Laura Murray, MD, English C. Flack, MD, MS, Kim Crum, RN, Jill Owen, RN, Andrew H. Smith, MD, MSCI, Prince Kannankeril, MD, MSCI

Background: Complete atrioventricular block (CAVB) is a major complication after cardiac surgery for congenital heart disease. Guidelines recommend pacemaker (PM) implantation for postoperative AV block not expected to resolve or persisting at least 7 days after surgery. We tested the hypothesis that clinical factors can predict recovery of conduction following postoperative CAVB.

Methods: Patients undergoing congenital heart surgery at our institution from September 2007 through June 2015 were prospectively enrolled in the parent study of postoperative arrhythmias. Patients with onset of complete AV block in the operating room were included in this study. Daily assessment of underlying rhythm was performed until demonstration of 1:1 conduction or PM implantation. Patients who died prior to recovery of conduction or PM implant were excluded. We retrospectively compared patients who required PM to those who did not.

Results: Of 1674 subjects enrolled, 58 (3.5%) developed postoperative CAVB. In 30 patients (52%) a PM was implanted on median postoperative day (POD) 10 (range 3-37). Twenty-six patients (45%) fully recovered AV conduction on median POD 3 (0-10) and did not require a PM. Two patients who died prior to recovering AV conduction or PM implant are excluded from further analysis. As shown in the table, age, gender, or presence of Down syndrome were not significantly different between groups. Patients with junctional acceleration [Junctional ectopic
tachycardia (JET) or accelerated junctional rhythm (AJR)] noted during complete AV block were more likely to recover 1:1 AV conduction and less likely to require PM (Odds Ratio 0.29, 95% CI 0.09-0.95).

**Conclusion:** Many patients with postoperative CAVB recover AV nodal conduction and do not require permanent pacemaker. The presence of junctional acceleration in the early postoperative period was the only identifiable predictor of recovery of AV conduction following congenital heart surgery.

**Table**

<table>
<thead>
<tr>
<th></th>
<th>Total (56)</th>
<th>Pacemaker (30)</th>
<th>No Pacemaker (26)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (months)</strong></td>
<td>4 (2-9.5)</td>
<td>5 (2.8-12.5)</td>
<td>3.5 (0.75-3)</td>
<td>0.177</td>
</tr>
<tr>
<td><strong>Gender (Female)</strong></td>
<td>30 (54%)</td>
<td>19 (63%)</td>
<td>11 (42%)</td>
<td>0.116</td>
</tr>
<tr>
<td><strong>Down syndrome</strong></td>
<td>14 (25%)</td>
<td>9 (30%)</td>
<td>5 (19%)</td>
<td>0.353</td>
</tr>
<tr>
<td><strong>Junctional acceleration</strong></td>
<td>18 (32%)</td>
<td>6 (20%)</td>
<td>12 (46%)</td>
<td>0.037</td>
</tr>
</tbody>
</table>

Values represent N (%) or Median (IQR)

Abstract 31

**Title:** Perventricular Melody Valve Placement: Results and Recommendations Based Upon Initial Experience

**Authors:** Aamisha Gupta MD, Zahid Amin MD, Damien Kenny MD, Massimo Caputo MD

**Institution:** Children’s Hospital of Georgia at Georgia Regents University, Augusta Georgia; Rush University Medical Center, Chicago Illinois

**Abstract:**

**Objective:** Perventricular Melody valve placement has been used as a bail-out approach in patients (pts.) who had failed attempted percutaneous placement. We used perventricular technique electively in a small group of patients who were not candidates for percutaneous approach. The objective of this study is to assess the feasibility, results, and to offer recommendations for optimal outcomes.  **Methods:**
The procedure was attempted in 5 pts. Pt. size precluded percutaneous approach in 4 and 1 pt. had limited venous access that would not allow placement of a large sheath. Tetralogy of Fallot was present in 3 and truncus arteriosus in 2. Weight ranged from 4.7-28.1 kg. All pts. had at least 2 median sternotomies. There were 4 pts. with RVOT conduits and 1 pt. had a trans-annular patch. Conduit size ranged from 14 to 21 mm. All pts. had severe conduit regurgitation and 4 had moderate to severe stenosis. All pts. met criteria to undergo surgical valve placement. Transesophageal echocardiography (TEE) was used in 2 pts. in addition to fluoroscopy. The steps of the procedure were similar to the perventricular procedure for VSD closure except that this procedure was performed using sub-costal approach without sternotomy with the sheath introduced through the diaphragmatic surface of the right ventricle. Results: Technical success was 100%. All pts. were pre-stented before Melody valve placement. In 2 pts. with absent pulmonary valve, the pre-stent migrated into the branch pulmonary artery during advancement of the delivery sheath. These stents were anchored in the branch pulmonary artery without any sequelae. Tricuspid valve chordal injury occurred in 1 pt. which resulted in moderate tricuspid regurgitation. This is 1 of the 3 pts. where TEE was not utilized. No pt. required conversion to cardio-pulmonary bypass. Follow up ranges from 1 month to 3 years. All pts. were doing well at the last follow up. Conclusions: Our initial experience demonstrates that perventricular pulmonary valve can be placed safely in small sized pts. Care needs to be utilized in pre-stented pts. to prevent stent migration. TEE may be utilized to ensure that tricuspid valve chordae are not being compromised. We conclude that the technique is feasible in small sized pts. and has a steep learning curve.

Abstract 32

Pediatric Cardiology Simulation: When to Give Fluids and Oxygen and When Not

Leslie Rhodes, MD¹, Ashley Love MSIV², Chrystal Rutledge, MD³, Nancy Tofil, MD, MEd³

¹University of Alabama School of Medicine, Department of Pediatrics, Division of Cardiology
²University of Alabama School of Medicine
³University of Alabama School of Medicine, Department of Pediatrics, Division of Pediatric Critical Care

Background: The assessment and management of a pediatric patient with a cardiac condition can be challenging. They frequently have a complex congenital cardiac lesion and are undergoing multiple stages of palliative repair, which will completely alter their physiology and how they will respond to supportive therapies. Many residents have had few opportunities, and thus are uncomfortable, caring for pediatric cardiac patients. In effort to address this a cardiac simulation module was developed. The
hypothesis is that by using realistic, hands on simulation cases residents will feel more comfortable as they better understand the cardiac physiology and management of pediatric cardiac diseases.

**Methods:** The cardiac simulation module is offered once a month for 2 hours and consists of four cases, with each case presenting with an acute problem. The participants include pediatrics residents on their pediatric cardiology rotation. The cases include myocarditis, hypoplastic left heart syndrome after stage 1 and stage 2 and Tetralogy of Fallot undergoing a “tet spell”. After each case, there is a debriefing with time devoted to review physiology. Emphasis is placed on appropriate use of interventions such as intravenous fluids, supplemental oxygen, and intubation, and how the physiology of some cardiac lesions or lesions in various stages of repair would respond.

**Results:** 24 learners have participated in the cardiac simulation module. Evaluations completed by the residents show that 100% of learners strongly agree that the simulation scenarios and debriefing are a valuable learning experience. In addition, 92% of learners strongly agree that the experience will improve their performance in actual clinical settings. Participant comments most frequently focused on the overall value of the initial review of cardiac anatomy and physiology, as well as how the physiology is altered by certain cardiac lesions.

**Conclusion:** The results from the evaluations are extremely positive, with most residents commenting on how beneficial the simulation courses were and appreciating the review of physiology. Future studies will evaluate the residents’ knowledge of cardiac physiology and management of cardiac lesions, both before and after the course.

Abstract 33

**POTASSIUM SUPPLEMENTATION PROTOCOL DECREASES INTRAVENOUS POTASSIUM BOLUS EXPOSURE AND COST IN THE PEDIATRIC CARDIOVASCULAR INTENSIVE CARE UNIT**

SL Abernathy¹, AB Moellinger¹, LA Rhodes², J Golden³, KM Wall², JA Alten²

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**BACKGROUND:** Potassium supplementation is frequent in the management of children with congenital heart disease. However, intravenous potassium chloride (IV KCL) boluses can lead to life-threatening arrhythmias. We report results of quality improvement (QI) project aimed at decreasing bolus IV KCL exposure.
METHODS: QI team developed potassium protocol aimed at maintaining potassium levels 3.5-5 mmol/L, via an algorithm with focus on enteral supplementation prior to hypokalemia development. All patients with: 1. IV diuretic management 2. serum potassium <4.5mmol/L and 3. urine output >0.5cc/kg/hr, had protocol initiated with KCL-containing IV fluids (If NPO) or enteral KCL. Protocolized adjustments were made daily based on potassium level and diuretic therapy. IV KCL boluses were limited to patients with potassium <2mmol/L (if asymptomatic) and symptomatic patients or high-risk patients with potassium <3mmol/L (history of arrhythmia, digoxin therapy, long QT syndrome). Serum potassium levels, number of IV and enteral KCL doses, cost per patient, and arrhythmia incidence were compared pre- and post-protocol.

RESULTS: 472 consecutive patients included (239 pre-protocol, 233 post-protocol). Table shows demographic and outcome data. There were no differences in demographics. IV KCL boluses decreased by 86%; enteral KCL doses increased by 54%. With protocol, there was an 80% reduction in episodes of hyperkalemia (K>6mmol/L), while incidence of hypokalemia (K<3mmol/L) was unchanged. Cost of potassium supplementation decreased an average 45% per patient. Arrhythmia incidence did not change.

CONCLUSION: Potassium protocol focused on enteral supplementation decreased IV KCL bolus exposure and cost while maintaining stable serum potassium. Potassium threshold <2mmol/L for IV KCL bolus did not increase arrhythmia incidence.

Abstract 34

PERIOPERATIVE FEEDING PROTOCOL IN NEONATES WITH CONGENITAL HEART DISEASE

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Introduction: Optimum perioperative feeding management is unknown; evidence suggests preoperative enteral nutrition and feeding protocols provide clinical benefit. We describe our institutional comprehensive neonatal perioperative feeding program since 10/2012.

Methods: All protocols are nurse initiated/managed; adherence to protocol is monitored/enforced. Preoperative feeding highlights: 1.Encourage breast milk (rate 65%); 2.Breast milk swabs every 2hrs if NPO or NG fed; 3.All stable neonates receive feeds: full PO/NG; exception: ductal dependent systemic circulation limited to 20-25/ml/kg/day. Postoperative feeding highlights: 1.Breast milk swabs while NPO 2.Nurse driven protocol (printed algorithm brought to bedside, figure 1) – feeds initiated when weaned to low dose inotropes. Start 1ml/kg/hr and advance every 4hrs to 6ml/kg/hr. Calories advanced daily to 130-145 kcal/kg/day after full volume reached. NG bolus after extubation, PO attempts 24hrs after extubation. Nurses monitor for signs of intolerance; adjust feeding per protocol. 3.Speech therapy
consult 4. Evaluation of swallowing and vocal cords prior to PO for predefined high-risk cohorts. 5. Early gastrostomy tube if unable to reach full volume PO feeds within ten days of feeding initiation.

**Results:** Comparing outcomes for protocol patients (n=139) against two years prior neonates (n=145), patients in protocolized era achieved 100cc/kg postoperative feeds sooner (*arterial switch and Norwood patients only*: median day 4 vs. 8, p<0.01), had greater discharge weight gain (487±320g vs. 299±247g, p<0.001), more gastrostomy tubes (25 vs. 14, p= 0.06) and shorter median hospital length of stay (*STAT 4, 5 and genetic syndrome only*: 25 vs. 31d, p=0.07).

**Conclusion:** A protocolized approach to neonatal perioperative feeding management eliminates unnecessary practice variation and improves clinical outcomes.

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**Abstract 35**

**COLLOID FLUID ADMINISTRATION IN THE FIRST 24 HOURS AFTER FONTAN OPERATION PREDICTS HOSPITAL LENGTH OF STAY**

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**BACKGROUND:** Fontan operation is a final common surgical palliation for single ventricle patients. Despite low mortality, it is associated with significant postoperative morbidity, including prolonged hospital length of stay (PLOS) and excessive chest tube (CT) drainage. We sought to identify variables present early in the clinical course that could predict patients at high risk for PLOS.

**METHODS:** Retrospective data was collected on all Fontan operations (84 patients) from 2008-2013. PLOS, defined as ≥ 12 days, was used as a marker for morbidity. Multivariate regression was used to determine covariates associated with PLOS. Continuous variables presented as medians (IQR).

**RESULTS:** Median age 3.5 years (IQR 3-5); weight 14.5 kg (IQR 13-17). No mortality. Duration of mechanical ventilation 7 hours (IQR 4-11), LOS 9 days (IQR 3-11), duration of CT drainage 6 days (IQR 5-8) at 15 ml/kg/day (IQR 9-20) for a total 83 ml/kg/LOS (IQR 49-128). Univariate risk factors evaluated for PLOS are shown in the table. No demographic, pre- or intraoperative variables had clinically important association with PLOS, including fenestration. In multivariate analysis, only greater 5% albumin administration in first 24 hours (p<0.001) and prolonged CT output were independently associated with PLOS. ROC curve analysis showed patients receiving > 25 ml/kg of 5% albumin in first 24 hours predicted PLOS (94% specificity, 93% sensitivity, AUC=0.95, p<0.001).
CONCLUSION: Increased colloid in first 24 hours post-CPB strongly predicts PLOS after Fontan operation; the impact on long term outcome is unknown. Studies aimed at modifying short and midterm outcomes after Fontan procedure could target this high-risk cohort.

Abstract 36

Percutaneous closure of Perimembranous Ventricular Septal Defects (Pm-VSDs) using the second generation Amplatz Vascular Occluders.

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Background: Previous attempts at percutaneous closure of Pm VSDs were abandoned because of incidence of heart block likely as a result of device rigidity and/or over sizing. The purpose of this study is to report the use of the softer second generation Amplatzer vascular occluders namely the Amplatzer Vascular Plug II (AVP II) and the Amplatzer Duct Occluder II (ADO II) for percutaneous closure of perimembranous ventricular septal defects (Pm VSDs).

Methods: Retrospective review of patients who underwent closure of Pm VSDs using AVP II or ADO II was performed.

Results: Between March 2013 and April 2015, 19 patients underwent percutaneous closure of the Pm VSD using the AVP II or the ADO II. AVP II was used in 9, ADO II in 10. Median weight was 13.2 Kg ± 19 (range 6.5 to 76); age 24 ± 79 months (range 11 to 352). Post procedure, 4 were noted to have new aortic insufficiency (AI); trivial in 3 & mild in 1 (unrelated to the device). Mild tricuspid regurgitation possibly device or procedure related was seen in 4. Residual flow through the device was common post procedure and disappeared in all but 2, graded as trivial in 1. 1 patient had small residual flow above the device. Average follow-up period was 7.3 months ± 7.6 (1 day – 25 months). There was no incidence of heart block, bacterial endocarditis, hemolysis, device embolization or fracture. The AI was trivial in 2, mild in 1 and resolved in 1.

Conclusions: Percutaneous closure of Pm VSDs using the softer new generation devices as the AVP II and the ADO II is feasible and safe. Longer follow up and larger series are needed.
Abstract 37

Myocardial Strain and Strain Rate in Pediatric Patients after Bone Marrow Transplantation
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Background
Systolic myocardial dysfunction has been reported following bone marrow transplantation (BMT). A prior study performed at our institution additionally described diastolic dysfunction in this patient population, occurring in 27% over a mean follow up of 4.5 years. Strain echocardiography may detect myocardial dysfunction earlier than other routinely-used measurements. We hypothesized that strain and strain rate analysis can detect early myocardial dysfunction in pediatric patients after BMT.

Methods
We used the patient population studied previously at our institution, all of whom underwent BMT between July 2003 and July 2010 and had at least two years follow up. Retrospective analysis was performed on the echo obtained 1 year post BMT and the most recent echo. Speckle tracking was used to determine peak left ventricular (LV) longitudinal strain and strain rate. Strain and strain rate results were compared with other routinely-used measurements of systolic (ejection fraction, shortening fraction) and diastolic function. Wilcoxon signed-rank and Mann-Whitney U tests were used for statistical analysis.

Results
A total of 22 patients were included with a median age of 6 years at the time of BMT (range of 6 months to 20 years). Of the 22 patients, 8 (36%) had evidence of abnormal strain (defined as strain less negative than -15%) at 1 year post BMT; this increased to 10 (46%) with abnormal strain over a median follow up time of 6.5 years (range of 2 to 8 years). While there was no significant decline in strain or strain rate from 1 year post BMT to the most recent follow up, there was an association with the presence of diastolic dysfunction. Strain and strain rate were more likely abnormal in those with evidence of diastolic dysfunction (defined as medial, lateral or mean E/E’ ratio >8) at most recent follow up. Compared to patients with normal diastolic function, those with diastolic dysfunction had less negative median strain (-14.0 vs. -16.7, p=0.049) and strain rate results (-0.79 vs. -0.97, p=0.004).

Conclusions
Myocardial dysfunction, both systolic and diastolic, is commonly seen in patients after BMT. Abnormalities in LV longitudinal strain and strain rate can also be seen in this patient population, and could relate to underlying diastolic dysfunction.
Abstract 38

ANTI-XA DIRECTED PROTOCOL FOR ANTICOAGULATION MANAGEMENT IN CHILDREN SUPPORTED WITH EXTRACORPOREAL MEMBRANE OXYGENATION

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INTRODUCTION: The optimal anticoagulation monitoring for extracorporeal membrane oxygenation (ECMO) is unknown. We report a protocol primarily utilizing anti-Xa to manage anticoagulation for pediatric cardiac ECMO.

METHODS: Retrospective review of 22 consecutive ECMO; 20 VA ECMO and two VV ECMO. Protocol overview: anti-Xa monitoring and heparin titration every hour until goal (0.4 to 0.8 IU/mL); once therapeutic, monitoring progressively spaced to every six hours. Antithrombin III (AT III) kept ≥ 100%. Post-cardiotomy bleeding patients managed without heparin. ACT not measured.

RESULTS: ECMO indications: 13 with cardiorespiratory failure, eight ECPR, one pulmonary hypertension. Median weight 4 kg, median age 12.5 days, median ECMO duration 88 hours, survival to discharge 50%. Mean heparin dose was 38±11 units/kg/hr. Four ± 3 ATIII doses were given per ECMO run. Eight patients were managed heparin-free for median nine hours. Compared to prior ACT-based protocol cohort (n=10), there were 20 fewer blood draws/day (p<0.001) to manage heparinization (Figure). 9% of anti-Xa levels were outside the therapeutic goal, requiring heparin adjustment, compared to 22% with the ACT-managed cohort (p < 0.01). 27% of patients had bleeding complications compared to 50% with ACT protocol (p=0.25). Oxygenator change (n=7) was associated with red blood cell administration and bleeding, but not with heparin-free period (p=0.39) or anti-Xa level. Mortality was higher among patients with circuit/oxygenator change (7/7 vs. 4/15, p<0.01)

CONCLUSIONS: Anti-Xa based ECMO heparin management protocol is feasible. It decreases blood sampling and heparin infusion adjustments. It does not appear to increase incidence of bleeding complications or circuit/oxygenator failure.
Impact of Hemolysis on Secondary Acute Kidney Injury in Children supported with Cardiac Extracorporeal Membrane Oxygenation

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Background: Intravascular hemolysis and generation of plasma free hemoglobin (PFH) occurs during extracorporeal membrane oxygenation (ECMO). PFH is a nitric oxide scavenger which causes diffuse microcirculatory vasoconstriction and may lead to acute kidney injury (AKI) secondary to tubular obstruction and oxidative stress. We hypothesize that elevated PFH levels are associated with development of prolonged AKI in children while supported with cardiac ECMO.

Methods: Retrospective review of 31 consecutive patients requiring cardiac ECMO October 2012 – August 2014. Daily PFH (mg/dL) was collected. Prolonged AKI in ECMO survivors was defined as need for renal replacement therapy (RRT) at 14 days after decannulation or at the time of death. PFH levels >70mg/dL were a priori defined as elevated. All patients received hemofiltration. RRT on ECMO was defined as peritoneal dialysis or in-line filter hemodialysis and/or replacement.

Results: Of 31 ECMO cases, 25(81%) had congenital heart disease; 19(52%) with single ventricle physiology (SVP). 18(58%) cases were postcardiotomy; 15(48%) with extracorporeal cardiopulmonary resuscitation (ECPR). Median age and weight were 14 days (IQR 7, 253) and 4.1 kg (IQR 3.2, 8.2). Median ECMO duration was 4.5 days (IQR 2.5, 8). Fifteen (48%) survived to discharge. Twenty (65%) required RRT while on ECMO. Twenty five (81%) patients survived to ECMO decannulation; 7(29%) had prolonged AKI. Median PFH of the entire cohort was 60 mg/dL. Patients with prolonged AKI had higher mean daily PFH (63 IQR 59,75 vs. 43 IQR 40,60; p<0.01), higher peak PFH (129 IQR 80,170 vs. 60 IQR 50,100; p=0.02), and percent of ECMO days with an elevated PFH (27 IQR 21, 55 vs. 0 IQR 0,30; p=0.01). PFH variables were not correlated with peak creatinine while on ECMO. Prolonged AKI was associated with days on ECMO (7.9 IQR 3.5, 30.9 vs. 3.1 IQR 1.8, 5.6; p=0.01), but not with peak serum creatinine on ECMO (1mg/dL IQR0.5, 1.3 vs. 1.5mg/dL IQR 0.7, 2.6; p=0.19), presence of SVP (p=0.38) or ECPR (p=1). Non-survivors to discharge had higher mean daily PFH (78 IQR 59,115 vs. 43 IQR 40,58 , p < 0.01), higher peak PFH (135 IQR 85,195 vs. 60 IQR 50,90; p = 0.03) and percent of ECMO days with an elevated PFH (59 IQR 22, 73 vs. 0 IQR 0,28; p=0.01). Peak PFH correlated with lowest daily mean arterial pressure (R²= 0.47, p < 0.01) and total red blood cell transfusion (ml/kg) on ECMO (R²=0.64, p < 0.01).

Conclusions: Elevated PFH during pediatric cardiac ECMO is associated with prolonged AKI and unadjusted non-survival to discharge. Measures to decrease PFH burden may improve kidney morbidity in ECMO survivors.
A PROTOCOLIZED APPROACH FOR EVALUATION OF SWALLOWING DYSFUNCTION AND ASPIRATION AFTER CARDIAC SURGERY IN NEONATES AND INFANTS

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Background: Vocal cord (VC) injury, swallowing dysfunction and aspiration are common in infants and neonates after cardiac surgery and may lead to morbidity and increased hospital length of stay (HLOS). We report our comprehensive protocolized approach to evaluation of swallowing and aspiration after cardiac surgery.

Methods: Retrospective analysis of quality improvement project aimed at improving feeding safety and decreasing HLOS. All patients <6mo that received evaluation (10/2012-7/2014) were included and compared to pre-protocol period (10/2010-9/2012, n=270). Protocol includes Fiberoptic Endoscopic Evaluation of Swallowing and Modified Barium Swallow for all aortic arch reconstructions and any neonate with genetic syndrome prior to oral feeds. Speech/occupational therapy evaluate all others; they administer first feeding and further evaluation as indicated (“other” cohort, below).

Results: 57/254 patients were evaluated. Median age 65d. Evaluation results shown in table. Incidence of aspiration and VC dysfunction was similar across cohorts. 25(44%) required gastrostomy tubes (GT); 18 for aspiration and seven for failure to take full PO. Of 24 patients with aspiration, 19 had minimal symptoms (“silent” aspiration). Despite similar mortality, STAT category, mechanical ventilation duration in the pre-protocol era; there was more VC dysfunction (22 vs. 14, p=0.16), more GT (25 vs. 17, p=0.15), shorter median HLOS (20 vs. 25d, p=0.07) and fewer intubation episodes or arrest secondary to aspiration (9 vs. 4, p=0.16) during protocol era.

Conclusion: Swallowing dysfunction and silent aspiration are common in patients with aortic arch reconstruction and genetic syndromes. Early identification and intervention may prevent aspiration-related morbidity and decrease HLOS. Application to other cohorts should be explored.