American Society of Echocardiography

29th Annual Scientific Sessions

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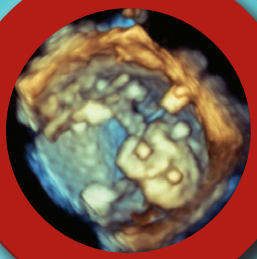
ASE 2018



JUNE 22-26

NASHVILLE ★ TN

Gaylord Opryland Resort
& Convention Center

★ ORIGINAL SCIENCE PRESENTATIONS ★

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★ #ASE2018 ★

Young Investigator's Award Competition (YIA)

Monday, June 25, 2018

2018 ARTHUR E. WEYMAN YOUNG INVESTIGATOR'S AWARD COMPETITION FINALISTS

Presented Monday, June 25, 3:30 PM-5:30 PM

Ventricular Function / Myocardial Mechanics
YIA-1

Valvular Heart Disease
YIA-2

Ischemic Heart Disease
YIA-3

Contrast Echocardiography
YIA-4

YIA-1

Extracting Knowledge from Geometric Shape of Echocardiography Data: Isolating Phenotypic Traits within the Systolic-Diastolic Dysfunction Continuum

Marton Tokodi[1], Alaa Omar[2], Megan Cummins[2], Sirish Shrestha[1], Christopher Bianco[1], Ali H. Amin[1], Muhammad Ashraf[1], Grace C. Verzosa[1], Partho P. Sengupta[1]. [1]WVU Heart & Vascular Institute, Morgantown, WV; [2]Icahn School of Medicine at Mount Sinai, New York, NY

Background: Heart failure (HF) patients go through cycles of compensation and decompensation related to changes in left ventricular function and filling pressure. We hypothesized that multivariable echocardiographic data will allow us to create a multidimensional network as patients sampled at different stages will trace the path traveled by HF patients through cycles of compensation and decompensation. **Methods:** We took a convenience population of 866 patients attending our outpatient clinic. After assessment of cardiovascular risk factors and demographic data, all patients underwent comprehensive echocardiographic evaluation including 2D and Doppler imaging. Topological Data Analysis (TDA), a novel unsupervised data-analytic technique was performed to reveal the concealed patterns in the collected data. Nine echocardiographic parameters were used to create the topological network. Model stability was further validated after adding 245 patients to the original cohort. **Results:** Topological data analysis revealed a loop, which when divided to four nearly equal quadrants (Figure 1) revealed unique HF phenotypes. Patients in the first quadrant had lower early diastolic transmitral flow to mitral annular relaxation velocity ratio (E/e'; p<0.001), tricuspid regurgitation velocities (p<0.001) and left ventricular mass index (p<0.001) compared to the rest of the population. The second quadrant had lower left atrial volume index (p<0.001) and early to late transmitral flow velocity ratio (E/A, p<0.001), while the third quadrant showed decreased e' (p<0.001) and increased E/e' (p<0.001) compared to the rest of the population. Quadrant four had the lowest ejection fraction (p<0.001). The Kaplan-Meier analysis revealed significant differences in major adverse cardiac events (p<0.001) and cardiac rehospitalization (p<0.024). The loop preserved its phenotypic structure even after addition of new cases. **Conclusion**: Cross-sectional echocardiography data can be utilized to create a multidimensional map that identifies different phenotypic presentations in heart failure as patients progress through cycles of compensation and decompensation within a looped disease space.

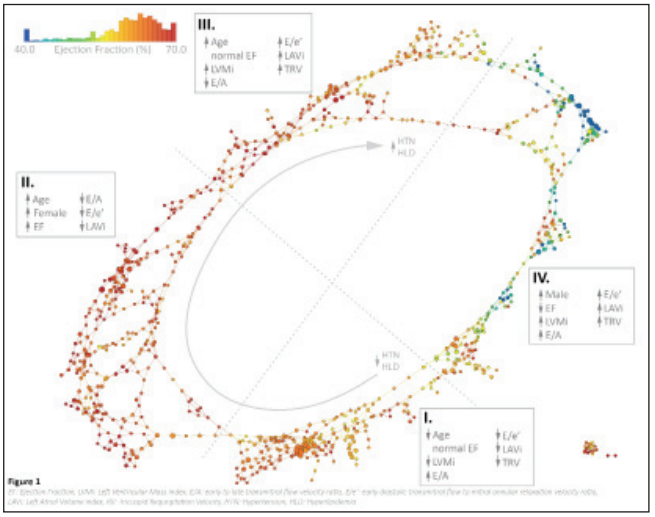


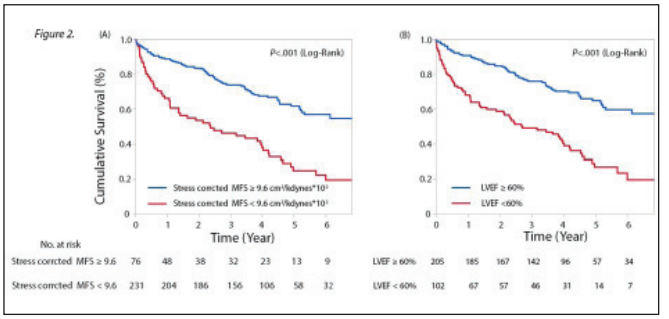
Figure 1

YIA-2

Mid-Wall Fractional Shortening in Aortic Stenosis Patients With or Without Reduced Ejection Fraction

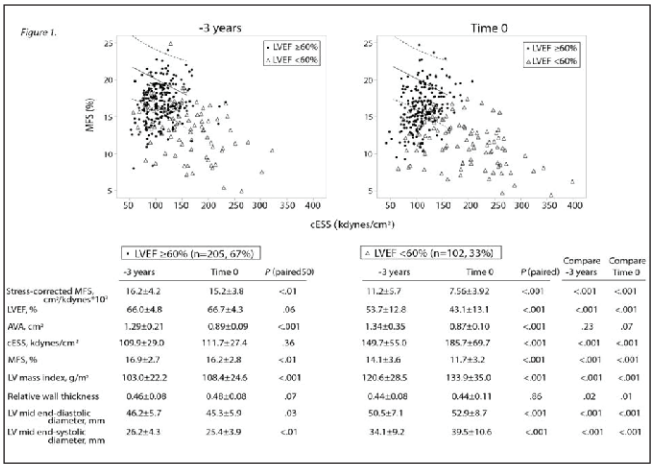
Saki Ito, Cristina Pislaru, William R. Miranda, Vuyisile T. Nkomo, Sorin V. Pislaru, Kevin L. Greason, Heidi M. Connolly, Patricia A. Pellikka, Bradley R. Lewis, Oh K. Jae. Mayo Clinic, Rochester, MN

Background: In aortic stenosis (AS), the left ventricle (LV) adapts to high intracavitary pressure through a concentric hypertrophic process to keep wall stress normal and LV ejection performance preserved. When wall stress exceeds the compensatory mechanism, LV contractility declines. Since LV ejection fraction (EF) is afterload dependent, we assessed temporal changes in LV contractility in patients with AS using midwall fractional shortening (MFS) at operating levels of wall stress (end-systolic circumferential wall stress (cESS)). **Methods:** From 2009 to 2012, patients with the first diagnose (time 0) of severe AS (aortic valve area (AVA) ≤1 cm^2), who had previous echocardiograms at -3±1 year were included. MFS and stress (afterload)-corrected MFS were compared between 2 patient groups based on EF at time 0 (<60% vs ≥60%). **Results:** A total of 307 patients, 205 patients (67%) had EF ≥ 60% (66.7±7.3%) and 102 (33%) had <60% (43.1±13.1%). MFS is plotted against cESS with the mean ± 95% prediction interval for normal controls (Fig 1). Most patients in EF ≥60% were in normal range. Patients with EF ≥60% had higher stress-corrected MFS compared to EF <60% (*P*<.001). In the EF ≥60% group, stress-corrected MFS significantly decreased (*P*<.001) over time, whereas the EF remaining preserved (*P*=.06). In EF <60% group, all measurements were impaired and further deteriorated as AS progressed. cESS was lower in EF ≥60% group (*P*<.001) and did not change during the study period (*P*=.36). In contrast, cESS dramatically increased in EF <60% group (*P* <.001). During a median follow-up of 3.5 years, stress-corrected MFS (Fig 2 (A), *P*<.001) as well as EF (Fig 2 (B), *P*<.001) were associated with higher mortality. **Conclusion:** Despite further increases in afterload as AS severity progresses, LV wall stress remains controlled and unchanged in patients with EF ≥ 60%, but it continues to increase in patients with LVEF <60%. Although both stress-corrected MFS and LVEF is related to worse prognosis, stress-corrected MFS appears to be a more sensitive tool than LVEF.



Young Investigator's Award Competition (YIA)

Monday, June 25, 2018



	• LVEF ≥60% (n=205, 67%)			△ LVEF <60% (n=102, 33%)				
	-3 years	Time 0	P (paired50)	-3 years	Time 0	P (paired)	Compare -3 years	Compare Time 0
Stress-corrected MFS, cm²/kdynes*10³	16.2±4.2	15.2±3.8	<.01	11.2±5.7	7.56±3.92	<.001	<.001	<.001
LVEF, %	66.0±4.8	66.7±4.3	.06	53.7±12.8	43.1±13.1	<.001	<.001	<.001
AVA, cm²	1.29±0.21	0.89±0.09	<.001	1.34±0.35	0.87±0.10	<.001	.23	.07
cESS, kdynes/cm²	109.9±29.0	111.7±27.4	.36	149.7±55.0	185.7±69.7	<.001	<.001	<.001
MFS, %	16.9±2.7	16.2±2.8	<.01	14.1±3.6	11.7±3.2	<.001	<.001	<.001
LV mass index, g/m²	103.0±22.2	108.4±24.6	<.001	120.6±28.5	133.9±35.0	<.001	<.001	<.001
Relative wall thickness	0.46±0.08	0.48±0.08	.07	0.44±0.08	0.44±0.11	.86	.02	.01
LV mid end-diastolic diameter, mm	46.2±5.7	45.3±5.9	.03	50.5±7.1	52.9±8.7	<.001	<.001	<.001
LV mid end-systolic diameter, mm	26.2±4.3	25.4±3.9	<.01	34.1±9.2	39.5±10.6	<.001	<.001	<.001

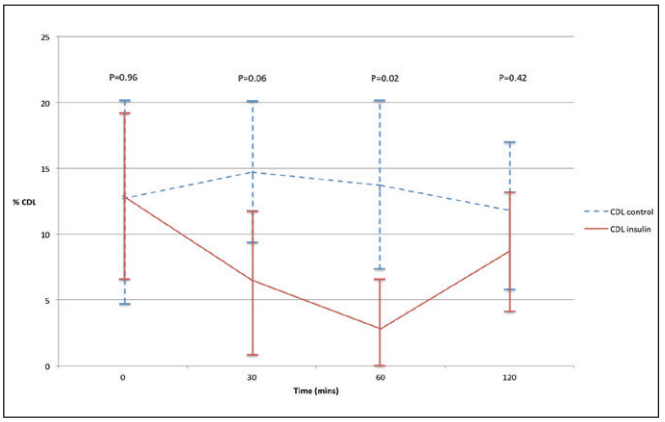
YIA-3

An Experimental Series Investigating the Effects of Hyperinsulinemic Euglycemia on Myocardial Blood Flow Reserve in Healthy Individuals and on Perfusion Defect Size in Patients Presenting with Acute Myocardial Infarction

Michael Chi Yuan Nam[1], Annelise Meneses[2], Chris Anstey[1], Tuppence Richman[1], Christopher Askew[2], Roxy Senior[3], Tony Stanton[1], Anthony Russell[4], Kim Greaves[1]. [1]Sunshine Coast University Hospital, Birtinya, Australia; [2]University of the Sunshine Coast, Sippy Downs, Australia; [3]National Heart and Lung Institute, Imperial College London, Royal Brompton Hospital, London, United Kingdom; [4]Princess Alexandra Hospital, Brisbane, Australia

Background: Hyperinsulinemic euglycemia (HE) increases myocardial blood flow reserve (MBFR) and may reduce myocardial ischemia. However, previous trials of insulin administration during myocardial infarction adopted variable insulin-dosing protocols which may have limited its benefit. Using insulin-dextrose (ID) infusions to induce HE, we conducted a two-phase study to determine: 1) how insulin duration, dose, and diabetes, affect MBFR response; 2) the effect of insulin on perfusion defect size in the immediate period following revascularisation of ST-elevation myocardial infarction (STEMI). **Methods:** MBFR was determined using adenosine/dipyridamole vasodilator myocardial contrast echocardiography (MCE). 1. Twelve participants received ID or saline infusion. MBFR was measured at four time intervals. Twenty-two received one of three insulin doses (0.5, 1.5, 3.0mU/kg/minute), and eleven insulin-resistance syndrome participants (five metabolic syndrome, six with type-2 diabetes) received 1.5mU/kg/minute, for 60 minutes. Baseline and 60-minute MBFR's were determined. 2. Immediately following revascularisation for STEMI, twenty participants received 1.5mU/kg/minute ID infusion or standard care for 120 minutes. MCE was performed at four time intervals to quantify contrast defect length expressed as a percentage of total LV endocardial border (%CDL). **Results:** 1. Insulin duration: MBFR increased with time in the ID group. Insulin dose: compared to baseline, MBFR increased in the 1.5mU/kg/minute (2.42±0.39 to 3.25±0.77, p=0.002), did not change in 0.5mU/kg/minute, and decreased in 3.0mU/kg/minute (2.64±0.25 to 2.16±0.33, p=0.02) groups. Diabetes: Compared to baseline, MBFR increased in healthy and metabolic syndrome participants (1.98±0.33 to 2.59±0.45, p=0.04). In type-2 diabetes, both baseline and ID MBFR were significantly lower than healthy participants, and MBFR increase was borderline significant (1.67±0.35 to 2.14±0.21, p=0.05). 2. STEMI: baseline %CDL was similar in both groups but with insulin decreased with time and significantly lower at 60 minutes (Fig 1). **Conclusion:** Insulin infusion duration, dose, and presence of diabetes, are important factors that affect MBFR. When given following revascularisation for STEMI, HE reduces %CDL.

Fig 1: Insulin-dextrose on %CDL



YIA-4

Endothelial Cell Repair Biophysics During Ultrasound and Microbubble Sonoporation

Brandon Helfield[1], Xucai Chen[2], Simon Watkins[2], Flordeliza Villanueva[2]. [1]Sunnybrook Research Institute, Toronto, ON, Canada; [2]University of Pittsburgh, Pittsburgh, PA

Ultrasound (**US**)-stimulated microbubbles (**MBs**) are emerging as non-viral gene delivery vehicles for the treatment of cardiovascular disease. The MB-cell interactions that facilitate nucleic acid delivery across cell membranes and into cells outside the vasculature, and hence strategies to optimize this platform, remain poorly understood. The objective of this work is to gain mechanistic insight into the biophysical context of reversible sonoporation. Live-cell 3D confocal microscopy was employed to image cultured human umbilical vein endothelial cells (**HUVECs**) during real-time sonoporation with lipid MBs exposed to a single US pulse (1 MHz, 8 μs; 0.1-0.9 MPa, n=54). Cell membrane impermeant propidium iodide (**PI**) was diluted into the media as a marker for sonoporation. We investigate the dynamics of plasma membrane perforation and interpret the findings with theoretical biophysical modeling. We then probe cytoskeletal re-organization during sonoporation using LifeAct. Finally, to assess remote biochemical signaling, a subset of experiments examines Ca^{2+} signaling, with and without the inhibition of gap junctions. We show for the first time that sonoporation generates transendothelial perforations (**TEPs**) that confer intracellular permeability only during their opening phase, a process consistent with biophysical modeling. TEP opening (and thus membrane permeability) is an order of magnitude faster than its resealing phase (p<0.001), suggesting a distinct biophysical origin between enhanced cellular versus vascular permeability. The extent of actin breaching at the TEP site increases with TEP area and PI uptake (p<0.001). The resealing phase is led by actin recruitment along the TEP rim and results in a membrane protrusion, suggesting exocytosis as a sonoporation healing mechanism (Fig. 1). Sonoporation initiates Ca^{2+} signaling to neighboring cells through gap junctions (p<0.001). While the opening of TEPs is largely passive, actin recruitment plays a significant role in their resealing and occurs over much longer timescales (1 min vs 10-20 min). Further, we have shown that gap junctions play a crucial role in biochemical signaling induced by sonoporation. This work contributes towards understanding the biophysical context of reversible sonoporation, necessary for its clinical translation.

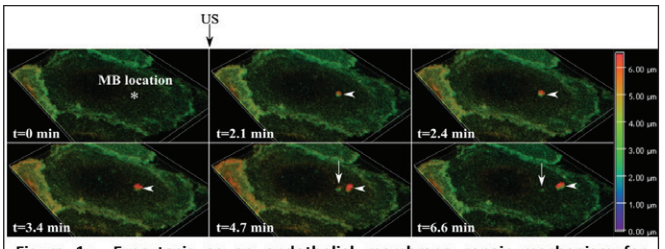


Figure 1: Exocytosis as an endothelial membrane repair mechanism for sonoporation. 3D depth color-encoded plasma membrane rendering highlighting membrane accumulation and protrusion (arrowhead) up to 4 μm above the membrane surface after a single sonoporation event. The individual microbubble location is denoted with an asterisk, and was insonicated with a 1 MHz, single 8-cycle pulse at 0.38 MPa between frames 1 and 2 (8 μs in duration). Endothelial cell permeability ceases by 1 min. post US. Note that around 5 min. post sonoporation, the membrane protrusion migrates from its original position (*i.e.* the pore site, denoted by the arrow). Cell viability was confirmed at 30 min. post-US.

Sonographer Research Award Competition (SIA)

Monday, June 25, 2018

2018 BRIAN HALUSKA SONOGRAPHER RESEARCH AWARD COMPETITION FINALISTS

Presented Monday, June 25, 1:15 PM-2:45 PM

Pediatric Heart Disease
SIA-1 and SIA-4

3D Echocardiography
SIA-2

Contrast Echocardiography
SIA-3

SIA-1

Pulmonary Artery Acceleration Time is a Poor Estimation of Severity of Pulmonary Hypertension in Pediatric Patients

Courtney Cassidy[1], Dale Burkett[1], Michal Schäfer[1], Mark Friedberg[2], D Dunbar Ivy[1], Pei-Ni Jone[1]. [1]Childrens Hospital Colorado, Aurora, CO; [2]The Hospital for Sick Kids, Toronto, ON, Canada

Background: Pulmonary artery acceleration time (PAAT) is a noninvasive method to evaluate pulmonary hemodynamics. Some data suggests this method is a reliable estimate of pulmonary hemodynamics measured by invasive right heart catheterization. The aim of this study is to evaluate PAAT between normal controls and pulmonary hypertension (PH) patients and to correlate PAAT with simultaneous invasive cardiopulmonary hemodynamics. **Methods:** At two institutions, PH patients underwent simultaneous 2-D echocardiography and right heart catheterization at baseline and acute vasoreactivity testing conditions. Pulmonary artery ejection time (PAET), PAAT and the PAAT/PAET ratio were evaluated. The pulmonary artery Doppler images were acquired on a GE E9 during cardiac catheterization with a decreased sweep speed to allow for multiple Doppler beat acquisition. The Doppler timing analyses were performed off-line using GE EchoPac software. At each condition, at least 3 Doppler cycles were averaged for each patient to account for beat-to-beat variability; where quality allowed, 5-10 Doppler cycles were measured. Data was compared to age-, gender-, and institution-matched normal controls who underwent 2-D echocardiography. Hemodynamic data sets were compared using student's *t*-test. Linear regression analysis was performed between PAAT/PAET and respective invasive hemodynamics at each vasodilatory testing condition. **Results:** Fifty-five controls were compared to 80 PH patients. PAAT and PAAT/PAET were significantly decreased in PH patients compared to controls (Table 1). There were no significant differences in PAET between the two groups. There were no correlations of PAAT/PAET to invasive hemodynamics in PH patients at baseline and during vasodilatory testing (Table 2). **Conclusions:** Although PAAT is shorter in PH compared to controls, it is not a reliable estimate of PH severity.

Table 1: Comparison of Pulmonary Artery Acceleration Time Between Controls and Pulmonary Hypertension Patients

	Control (n=55)	PH (n = 80)	P-value
Age	9 (4 – 14)	9 (3 -14)	0.769
BSA	1.19 ± 0.52	1.11 ± 0.50	0.322
Sex (Female)	33 (60%)	52 (65%)	0.554
PAET	307 ± 40	312 ± 52	0.532
PAAT	106 ± 27	93 ± 27	0.006
PAAT/PAET	0.34 ± 0.06	0.30 ± 0.08	0.001
sPAP		53 ± 20	
mPAP		34 ± 19	
mPAP/MAP		0.58 ± 0.25	
PVRi		5.8 (3.9 – 10.3)	
PVR/SVR		0.38 (0.25 – 0.60)	

BSA= body surface area, PAET= pulmonary artery ejection time, PAAT= pulmonary artery acceleration time, sPAP= systolic pulmonary artery pressure, mPAP= mean pulmonary artery pressure, MAP= mean arterial pressure, PVRi= pulmonary vascular resistance index, PVR= pulmonary vascular resistance, SVR= systemic vascular resistance

Table 2: Pulmonary Artery Acceleration Time to Pulmonary Artery Ejection Time Ratio Correlated to Invasive Hemodynamics in Pulmonary Hypertension Patients

Condition 1	Beta ± SE	R^2	R	P-value
sPAP	-0.9 ± 0.7	0.0245	-0.02	0.1856
mPAP	-0.7 ± 0.5	0.0247	-0.02	0.1585
mPAP/MAP	-0.04 ± 0.04	0.0158	-0.01	0.3085
PVRi	0.03 ± 0.16	0.0076	0.01	0.8143
PVR / SVR	-0.016 ± 0.035	0.0031	0	0.6498
Condition 2				
sPAP	-0.03 ± 0.6	0.00001	0	0.9557
mPAP	0.7 ± 0.9	0.0032	0.06	0.4132
mPAP/MAP	-0.06 ± 0.03	0.0764	-0.27	0.0495
PVRi	-0.07 ± 0.1	0.0066	-0.08	0.5703
PVR / SVR	-0.03 ± 0.03	0.0262	-0.03	0.2609
Condition 3				
sPAP	0.6 ± 0.6	0.0484	0.22	0.3801
mPAP	0.7 ± 0.9	0.0385	0.19	0.4349
mPAP/MAP	0.03 ± 0.05	0.0029	0.05	0.6111
PVRi	0.23 ± 0.20	0.0775	0.28	0.2631
PVR / SVR	0.41 ± 0.43	0.0556	0.24	0.3621

sPAP= systolic pulmonary artery pressure, mPAP= mean pulmonary artery pressure, MAP= mean arterial pressure, PVRi= pulmonary vascular resistance index, PVR= pulmonary vascular resistance, SVR= systemic vascular resistance

SIA-2

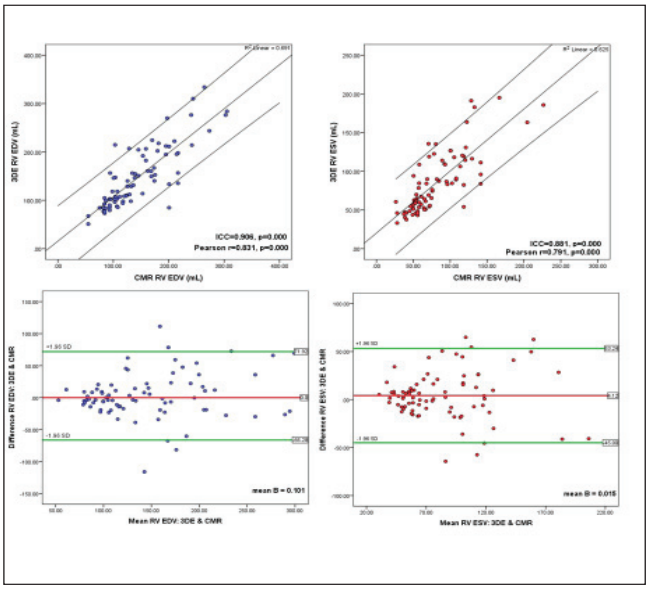
Evaluation of 3D Echocardiography for Assessment of Right Ventricular Volume & Comparison with Cardiac Magnetic Resonance Imaging in Pediatric Patients

Kelly Thorson, Brandy Clark, Lindsay Provenzano, James Prochzka, Miguel S. Restrepo. Valley Children's Hospital, Madera, CA

Background Evaluation of the right ventricular volume is a clinically relevant assessment that carries prognostic significance and defines management in pathologies that compromise the right ventricle. Measurement of volumes by echocardiography has been challenging. Cardiac magnetic resonance imaging (CMR) is the reference standard, but has significant drawbacks including equipment cost, availability, professional expertise, and need for sedation. Three-dimensional echocardiography (3DE) has become a useful tool and contemporary semi-automated software versions show the potential for accurate evaluation of right ventricular volumes. **Methods** Our archive and databases were retrospectively queried for patients from 2013-2017 where both a CMR and 3DE right ventricular volumes were performed. Right ventricular volumes were prospectively re-measured by 3 experienced investigators using commercially available Right Ventricular Analysis 2 (TomTec), semi-automated tracking software. Indices including right ventricular end-diastolic volume (EDV) and right ventricular end-systolic volume (ESV) were measured. Interuser variability and intrauser variability were assessed by intraclass correlation coefficients (ICC). Comparison with CMR was assessed by limits of agreement of Bland-Altman and by Pearson's r correlation. Variance was evaluated by the average of the coefficient of variance (CV) for the indices measured. Statistical Analysis was performed using SPSS 24 (Microsoft). **Results** 91 subjects were identified and 12 subjects were excluded for significant weight differences between studies and or ventricular volumes that were not able to be quantified (n = 79). Correlation of EDV and ESV between 3DE and CMR was good. Inter-observer and intraobserver agreement was excellent with EDV and ESV. **Conclusions** Assessment of right ventricular volume by 3DE represents a feasible, non-invasive way to evaluate and track the right ventricular volume that is reproducible and shows a good correlation with CMR.

Sonographer Research Award Competition (SIA)

Monday, June 25, 2018



Demographics, Intermethod comparison, and Interobserver and Intraobserver Variability

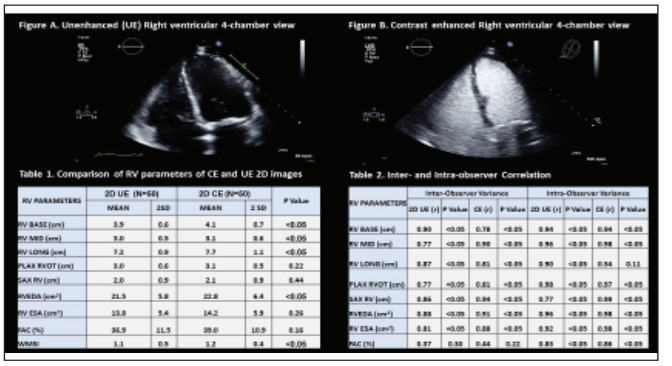
Demographics		Total	Variable	ICC(p)	CV avg (%)	Pearson r(p)
Subjects		91-12= n 79	Intermethod Comparison(3DE and CMR)			
Male		46 (58%)	EDV	0.91 (0.000)	11.6	0.83 (0.000)
Female		33 (42%)	ESV	0.88 (0.000)	15.1	0.79 (0.000)
Age Range (y)	0-32	79	Interobserver variability	ICC(p)	CV avg (%)	
Age by Group	0-5	11 (25%)	EDV	0.94 (0.000)	12.5	
	5-10	41 (52%)	ESV	0.94 (0.000)	14.2	
	10-18	20(25%)	Intraobserver Variability	ICC(p)	CV avg (%)	Pearson r(p)
	>18	7(9%)	EDV	0.95-0.96	9.1	0.93 (0.000)
BSA		Range 0.43-1.97 mean 1.07	ESV	0.93-0.95	11.2	0.90 (0.000)

SIA-3

Feasibility of Contrast Echocardiography to Assess Right Ventricular Size and Function

Jason B. Pereira, Mohammed Essa, Elise Meoli, Lissa Sugeng. Yale-New Haven Hospital, New Haven, CT

Background: Right ventricular (RV) size and function can have an important impact on clinical outcomes. Accurate assessment of the RV requires multiple imaging windows and may not be feasible due to rib shadowing, obesity, and lung disease. There is limited data on the use of contrast echocardiography (CE) to better delineate the RV. Our study goal was to determine the feasibility of using an imaging enhancing agent to evaluate RV size and function, and whether it improves ability to identify wall motion abnormalities compared to unenhanced echo images (UE). **Methods:** Fifty patients referred for a clinically indicated echocardiogram who required CE for left ventricular opacification (LVO) were included in this study. Patients with atrial or ventricular arrhythmias were excluded. Our transthoracic echocardiogram includes multiple two-dimensional echocardiographic views of the RV. Parasternal long-axis, papillary level short-axis, apical 4-chamber and apical RV focused views were obtained with and without CE. Optimal contrast enhanced visualization of the RV was achieved after full LVO to avoid the attenuation of the medial and basal RV segments. The dedicated RV view was acquired by maintaining a non-foreshortened left ventricular 4-chamber view and narrowing the sector size to focus on the RV. Basal (RVBASE), mid (RVMID), and longitudinal (RVLONG) RV end-diastolic dimensions, RV end-diastolic area (RVEDA), RV end-systolic area (RVESA), and fractional area change (FAC) were measured on the non-contrast and the contrast enhanced images. In the RV focused view, RV contractility was assessed with a wall motion score index (WMSI). **Results:** RVBASE, RVMID, RVLONG, and RVEDA were significantly larger for CE versus UE measurements. (Table 1), whereas there was no significant difference with PLAX RVOT, SAX RV, RVESA, and FAC. In the apical RV focused view, there was a significant difference in WMSI (1.1±0.5 vs 1.2± 0.4; P <0.05). Intra- and inter-observer variability were excellent for RVBASE, RVMID, PLAXRVOT, SAXRV, RVEDA, and RVESA for both the UE and CE images (Table 2). **Conclusion:** Expanding the role of CE to include evaluation of RV size, function and wall motion is feasible and could prove very advantageous in improving the assessment of the RV.



SIA-4

The Addition of Subdiaphragmatic Doppler to Assess Vascular Steal Phenomenon in Hemodynamically Significant PDAs

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Background: Although there are various echocardiographic methods to measure patent ductus arteriosus (PDA) , there is no quantifiable measure to determine if there is a vascular steal from the abdominal organs. If the PDA is as large as the branch pulmonary arteries, then effectively 1/3 of the blood that should go to the abdomen is going back toward the lung. This suggests a vascular steal from the abdomen causing potential ischemia to the bowel and kidneys. The Superior Mesenteric Artery (SMA) and renal artery spectral Doppler waveforms have been added to evaluate abdominal perfusion. Absence of diastolic flow or staccato flow where there is a loss of end-systolic flow is prognostic of a vascular steal phenomenon. **Methods:** Two hundred and five consecutive premature infants underwent pediatric echocardiograms with the diagnosis of PDA. Image quality was considered good in l98/205 cases and adequate in the other 7 cases. All echocardiograms were performed by experienced RDCS credentialed sonographers using the Philips IE 33 echocardiographic unit (Philips, Andover, MA). The institutionally accepted echocardiographic protocol was performed on all cases. The additional two abdominal vascular Doppler waveforms included a pulsed wave spectral Doppler waveform of the SMA and Renal artery at the vessel ostia off of the abdominal aorta. These vessel Doppler waveforms were scored as either 0= normal (preserved diastolic flow), 1= reduced diastolic flow, 2= absent diastolic flow, and 3= staccato or absent end-systolic and absent diastolic flow. **Results:** In 173/205 infants the PDA measurements did not meet the echocardiographic criteria of hemodynamically significant. In these 173 patients there was preserved diastolic flow in the SMA and renal artery in diastole. 13 cases showed hemodynamically significant PDAs by echocardiographic criteria but still had preserved diastolic flow in the SMA and renal artery. These cases were medically treated. The remaining 19 cases showed significant PDAs by echocardiographic criteria and either absence of diastolic flow in the SMA and renal artery or staccato flow. All 19 of these cases were ligated and followed at 48 hours post op to reassess ventricular function and the flow to the bowel and kidney. In 100% of these cases there was preserved diastolic flow. **Conclusions:** The addition of subdiaphragmatic vessel interrogation (SMA and renal artery) in all infants with hemodynamically significant PDAs provides a quantitative way to determine if a vascular steal is occurring secondary to the PDA. This should assist physicians with clinical management of premature infants with PDAs.

Oral Abstracts (OA)

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ORAL ABSTRACTS

Presented Saturday, June 23 through Tuesday, June 26

Ventricular Function / Myocardial Mechanics
OA-01

Cardio-Oncology
OA-02

Contrast Echocardiography
OA-03

Pediatric Heart Disease
OA-04 through OA-12 and OA-14

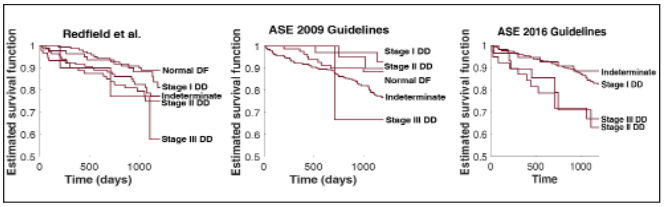
Echocardiography in Systemic Disease (DM, HTN, Obesity) / Pericardial Disease / Primary Myocardial Disease
OA-13

OA-01

Performance of Diastolic Function Classification Systems to Predict Incident Death or Hospitalization for Heart Failure in a VA Population

Yuchi Han, Srinath Adusumalli, Dinesh Jagasia, Bonnie Ky, Tiffany Chen, Marietta Ambrose, Rupal O'quinn, Scott Akers, Frank Silvestry, Victor Ferrari, Marielle Scherrer-Crosbie, Julio Chirinos. University of Pennsylvania, Philadelphia, PA

Background: Various classification systems for left ventricular (LV) diastolic function have been proposed and utilized over the last decade, including the American Society of Echocardiography (ASE) 2009 and 2016 guidelines. There have been studies validating the guidelines based on LV filling pressures, but how these guidelines predict patient outcomes is unknown. **Methods:** We studied adults with and without heart failure in a prospectively enrolled VA cohort. We measured diastolic function using standard Doppler methods and biplane left atrial volume. We excluded patients with tachycardia, E to A fusion, atrial fibrillation, atrial flutter, mitral valve dysfunction (>2+ regurgitation and mitral stenosis), and pericardial disease. We classified subjects into categories of diastolic function according to 3 methods: ASE guidelines 2009, ASE guidelines 2016, and previously utilized classification by Redfield *et al.* Incident heart failure hospitalizations and death were adjudicated over a median follow-up of 38.8 months. **Results:** We included 482 patients (mean age 62.4±0.7 years, 94% male) in the analysis. During follow-up, 48 subjects experienced a heart failure admission, 55 died, and 93 experienced a composite event. In general, there was poor agreement between classification schemes. The kappa statistics for concordance were as follows: Redfieldvs. ASE 2016: 0.081±0.017; ASE 2016 vs. ASE 2009: 0.047±0.013; ASE 2009 vs. Redfield: 0.25± 0.027. Kaplan Meier survival curves for diastolic function categories for the 3 systems are shown in Figure 1. Subjects who could not be classified (indeterminate category) demonstrated a risk similar to those with stage II or stage III diastolic dysfunction (DD) when using the ASE 2009 guidelines or the Redfield classification. In contrast, subjects in the indeterminate DD category according to the ASE 2016 guidelines demonstrated a lower risk, comparable to subjects with stage 1 DD. The new ASE guidelines demonstrated the smallest proportion of indeterminate or non-classified cases. **Conclusions:** There is limited agreement between existing classification systems for diastolic function. All classification systems provide important prognostic information, and the new ASE guidelines minimize the number of indeterminate/unclassified individuals.

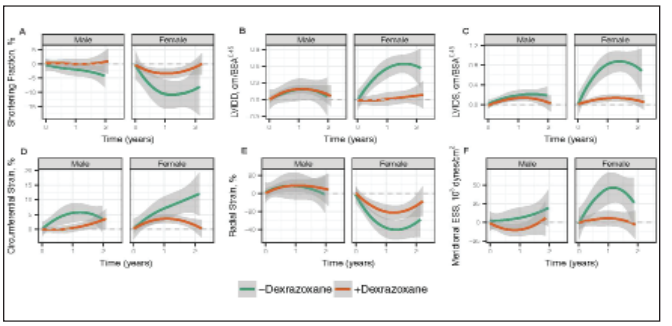


OA-02

Dexrazoxane Preferentially Mitigates Adverse Changes in Cardiac Structure and Function in Female Children with Sarcoma Receiving High-Dose Anthracycline Therapy

Hari K. Narayan[1], Mary Putt[2], Nikitha Kosaraju[2], Alejandro Paz[2], Shivani Bhatt[3], Theodore Plappert[2], Laura Mercer-Rosa[3], Saro H. Armenian[4], Ami Desai[5], Richard B. Womer[3], Bonnie Ky[2]. [1]The University of California San Diego, San Diego, CA; [2]The University of Pennsylvania, Philadelphia, PA; [3]Children's Hospital of Philadelphia, Philadelphia, PA; [4]City of Hope, Duarte, CA; [5]The University of Chicago, Chicago, IL

Background: We sought to determine how sex and dexrazoxane therapy influence the early cardiotoxic effects of high-dose anthracyclines in pediatric sarcoma. **Methods:** In a retrospective cohort of 85 children (44% female, 73% dexrazoxane exposed) with sarcoma receiving doxorubicin (median dose 375 mg/m^2 [interquartile range 375, 450]), echocardiography measures prior to, early after (within 6 months of therapy completion), and 1-2 years after therapy were quantified by a blinded observer. At each follow-up, multivariable, propensity-adjusted linear regression modeled the changes in left ventricular (LV) shortening fraction (SF) and LV structure, strain, and wall stress for subgroups divided by sex and dexrazoxane exposure. Likelihood ratio tests assessed the interaction of sex and dexrazoxane exposure in determining these changes. **Results:** Clinical characteristics (age, sex, race, doxorubicin dose, and chest radiation) were similar among those who did and did not receive dexrazoxane. Early after therapy, among subjects not treated with dexrazoxane, males (n=15) developed increased cavity size and worsened circumferential strain, while females (n=8) developed worsened SF, circumferential and radial strain, and increased cavity size and wall stress (Figure 1, Table 1). In males treated with dexrazoxane (n=33), deterioration of circumferential strain was mitigated by 3.4%. In females treated with dexrazoxane (n=29), declines in SF (5.7% difference) and increases in cavity size and wall stress were mitigated (all p<0.05). In interaction analyses, females had greater protection from SF declines and cavity dilation with dexrazoxane (p<0.05). These early findings persisted 1-2 years after doxorubicin therapy. **Conclusions:** Early and sustained alterations in LV structure and function were seen in children with sarcoma after high-dose doxorubicin, with adverse changes and dexrazoxane's protective effects more pronounced in females. Sex-specific considerations may be important in the use of dexrazoxane.



Changes in Echocardiography Measures Early After Anthracycline Therapy

Echocardiography Measure	Male, -Dexrazoxane (n=15)	Male, +Dexrazoxane (n=33)	Female, -Dexrazoxane (n=8)	Female, +Dexrazoxane (n=29)	P (Interaction)
SF, %	-1.0 (-3.4, 1.4)	-0.5 (-2.1, 1.1)	-8.5 (-11.7, -5.2)	-2.8 (-4.4, -1.1)	0.019
LVIDD, cm/BSA$^{0.45}$	0.1 (0.0, 0.3)	0.2 (0.1, 0.3)	0.4 (0.2, 0.6)	-0.1 (-0.2, 0.1)	<0.001
LVIDS, cm/BSA$^{0.45}$	0.2 (0.0, 0.3)	0.1 (0.1, 0.2)	0.7 (0.5, 0.8)	0.1 (0.0, 0.2)	<0.001
Posterior Wall Thickness, cm/BSA$^{0.4}$	0.0 (-0.1, 0.0)	0.0 (0.0, 0.0)	0.0 (-0.1, 0.0)	0.0 (0.0, 0.0)	0.85
LV Mass, gr/BSA$^{1.25}$	2.2 (-4.6, 9.0)	6.1 (1.5, 10.8)	6.3 (-3.1, 15.7)	-2.4 (-7.3, 2.6)	0.043
Relative Wall Thickness	-0.02 (-0.04, 0.01)	-0.02 (-0.03, 0.00)	-0.05 (-0.08, -0.01)	0.00 (-0.02, 0.02)	0.046
Circumferential Strain, %	3.3 (0.4, 6.2)	-0.1 (-1.8, 1.6)	4.6 (0.6, 8.6)	4.0 (2.2, 5.8)	0.27
Radial Strain, %	-0.8 (-11.8, 10.2)	3.8 (-2.7, 10.4)	-20.6 (-36.1, -5.1)	-10.6 (-17.9, -3.4)	0.58
Meridional ESS, 10^3 dynes/cm^2	2.5 (-10.5, 15.4)	-5.4 (-14.5, 3.6)	27.6 (7.7, 47.6)	-1.5 (-11.0, 7.9)	0.089
Circumferential ESS, 10^3 dynes/cm^2	-2.8 (-16.1, 10.5)	-9.9 (-19.2, -0.6)	13.9 (-6.7, 34.6)	-4.9 (-14.7, 4.8)	0.36

Linear regression modeled the change in each echocardiography measure between baseline and early after anthracycline therapy (within 6 months of therapy completion) in the overall cohort, adjusting for the propensity to receive dexrazoxane, age, race, sex, dexrazoxane exposure, and the interaction between sex and dexrazoxane exposure. Predicted marginal means and 95% confidence intervals are depicted for each subgroup divided by sex and dexrazoxane exposure.

Interaction P-values are derived from likelihood ratio tests comparing models including the interaction between sex and dexrazoxane exposure and models with the two variables entered in additive fashion.

BSA=body surface area; ESS=end-systolic stress; LV=left ventricular; LVIDD=left ventricular inner dimension in diastole; LVIDS=left ventricular inner dimension in systole; SF=shortening fraction

Oral Abstracts (OA)

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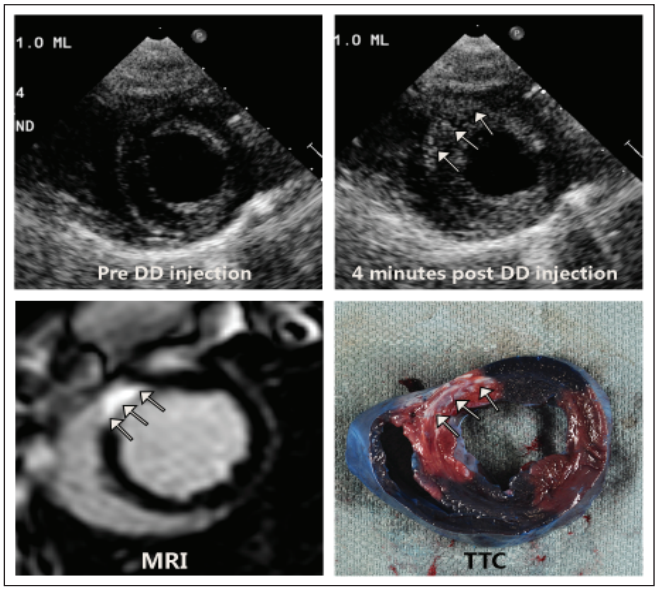
OA-03

Delayed Enhancement Imaging with Intravenous Definity Droplets to Selectively Enhance the Myocardial Infarct Zone: Correlation with Delayed Enhancement Magnetic Resonance Imaging in a Large Animal Model

Songita A. Choudhury, Feng Xie, Thomas R. Porter. University of Nebraska Medical Center, Omaha, NE

Background: Nanometer-sized droplets can be formulated from commercially available microbubbles at the bedside. Since they are sub-micron in size, we have shown that they cross defective endothelial barriers and accumulate within non-viable tissue. Because these droplets would be moving slower and more randomly than in the normal myocardial zones or left ventricular (LV) cavity, we hypothesized that unique transthoracic harmonic activation sequences could be utilized to selectively enhance the infarct zone (IZ). **Methods:** Pigs (n=5) underwent prolonged left coronary artery balloon occlusion (90 minutes) followed by reperfusion. At 48-72 hours post reperfusion, delayed enhancement magnetic resonance imaging (DE-MRI) with intravenous gadolinium to delineate the infarct extent was performed. Subsequent to this, transthoracic two dimensional harmonic or ultrasharmonic imaging (1.3-1.7 Mhz fundamental) at a high mechanical index (≥1.0) and reduced frame rate (10 Hz) was performed at four to six minutes following a 1.0 ml injection of Definity droplets. Correlations between hyperenhanced area by DE- MRI and acoustic activation imaging (AAI) were obtained. Additional correlations were determined with with post mortem triphenyl tetrazolium chloride (TTC) staining. **Results:** Focal transmural infarcts of varying area extent were observed with DE-MRI and TTC. Selective acoustic activation within the infarct zone was observed in four of five pigs, resulting in background subtracted contrast of just the infarct zone (Figure). The correlation between the contrast enhanced zone and infarct size by TTC was excellent (r=0.96, p<0.05). **Conclusion:** Using a slow frame rate and high mechanical index single pulse harmonic activation, selective activation of Definity droplets within the infarct zone is achievable. This technique can be utilized for non-invasive detection and quantification of myocardial scar.



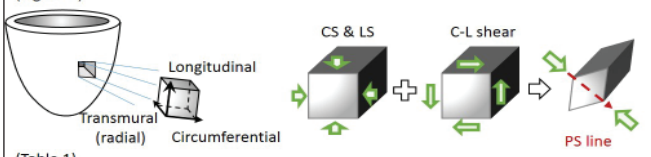
OA-04

Insights into Mechanisms of Decreasing Cardiac Function in Single Right Ventricle from Novel Three-Dimensional Principal Strain Analysis

Tomoyuki Sato[1], Renzo JC Calderon-Anyosa[1], Gianni Pedrizzetti[2], Anirban Banerjee[1]. [1]Children's Hospital of Philadelphia, Philadelphia, PA; [2]University of Trieste, Trieste, Italy

Background: Three-dimensional (3D) speckle tracking echocardiography (STE) computes complete 3D strain, of which principal strain (PS) is the most intense component. It acts along principal direction of contraction. In myocardium, layers of counterwound fibers crossing in different directions produce PS in an intermediate, dominant direction. PS is an integration of deformations that occur in multiple directions i.e. circumferential (C) strain, longitudinal (L) strain, and C-L shear (known as twist) (Fig 1). As an integrated entity PS may simplify tissue deformation, obviating need to measure various strains in various directions. Rearrangements of myofibers under pressure and volume overload have been reported in right ventricle (RV). The aim of this study was to evaluate the intensity and direction of PS in single RV (SRV) supporting systemic circulation. **Methods:** We prospectively analyzed 52 patients (Age: 10.4 ± 4.8 yrs.) with SRV resulting from hypoplastic left heart syndrome after Fontan completion. 3DSTE was performed using TomTec LV oriented software applied to SRV. Endocardial surfaces from 3DSTE were defined by the coordinates of material points, and were processed by MatLab. 3D ejection fraction (EF), end-diastolic volume index (EDVi), global PS (GPS), and PS lines were computed. PS lines oriented in left-handed direction were expressed as negative values (blue lines), while those in right-handed direction as positive values (red lines) (Fig 2). Subjects were divided into three groups (Table 1) based on EF. PS was compared among 3 walls, anterior free-wall (Ant-FW), posterior free-wall (Post-FW), and septum. **Results:** See Table 1. PS of Post-FW and septum were significantly higher than that of Ant-FW in Group 1 (EF>55%) (p < 0.01). PS of Post-FW and septum decreased significantly between group 1 & 2 (EF 48-55%). PS of all walls decreased significantly between group 2 & 3 (EF<48%). Figure 2 depicts angles of PS lines in three groups. PS angles of Post-FW became steeper (changed from yellow to red), with decreasing EF. **Conclusion:** PS of Post-FW and septum may play an important role in SRV function. PS lines provide a physiologic map of contraction, analyzing not only force of contraction but also its directional pattern. This is an important first step for in-depth analysis and quantification of SRV function.

(Figure 1)

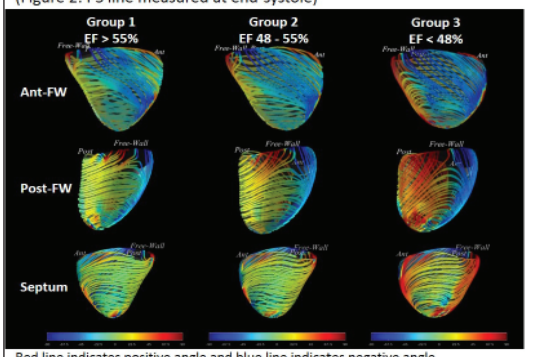


(Table 1)

	Group 1 (EF > 55%) n = 15	Group 2 (EF 48 - 55 %) n = 21	Group 3 (EF < 48 %) n = 16	P *	Post hoc analysis Group 1 vs 2	Group 1 vs 3	Group 2 vs 3
Global analysis							
EF (%)	57.4 ± 2.0	51.5 ± 1.9	40.7 ± 6.2	< 0.01	< 0.01	< 0.01	< 0.01
EDVi (ml/m²)	81.0 ± 16.9	88.2 ± 23.1	102.5 ± 29.9	NS			
GPS (%)	-33.2 ± 2.4	-29.8 ± 2.2	-22.6 ± 4.6	< 0.01	< 0.05	< 0.01	< 0.01
PS in three parts of walls (%)							
Ant-FW	-28.6 ± 4.0	-28.4 ± 3.8	-21.4 ± 5.8	< 0.01		< 0.01	< 0.01
Post-FW	-34.4 ± 3.9	-30.2 ± 2.7	-23.9 ± 4.8	< 0.01	< 0.01	< 0.01	< 0.01
Septum	-37.8 ± 2.4	-31.8 ± 5.0	-23.1 ± 6.9	< 0.01	< 0.01	< 0.01	< 0.01
PS line angle in three parts of walls (°)							
Ant-FW	-22.8 ± 11.7	-25.1 ± 10.3	-29.8 ± 7.4	NS			
Post-FW	4.0 ± 12.8	15.3 ± 10.4	20.5 ± 12.9	< 0.01	< 0.05	< 0.01	
Septum	11.6 ± 8.6	9.2 ± 7.7	17.0 ± 7.3	< 0.05			< 0.05

Data expressed as mean ± SD. Significant parameters are highlighted in bold.
* One-way ANOVA or Kruskal-Wallis analysis

(Figure 2: PS line measured at end-systole)



Red line indicates positive angle and blue line indicates negative angle.

OA-05

Longitudinal Change in Echocardiographic Parameters of Cardiac Function in Childhood Cancer Survivors: A Multicenter Study

William L. Border[1], Ritu Sachdeva[1], Kayla L. Stratton[2], Saro H. Armenian[3], Aarti Bhat[4], David E. Cox[4], Kasey J. Leger[4], Wendy M. Leisenring[2], Lillian R. Meacham[1], Karim T. Sadak[5], Shanthi Sivanandam[5], Paul C. Nathan[6], Eric J. Chow[2]. [1]Children's Healthcare of Atlanta, Atlanta, GA; [2]Fred Hutchinson Cancer Research Center, Seattle, WA; [3]City of Hope, Duarte, CA; [4]University of Washington, Seattle, WA; [5]University of Minnesota, Minneapolis, MN; [6]University of Toronto, Toronto, ON, Canada

Background: Childhood cancer survivors have an increased risk of cardiomyopathy (CDM), and receive serial echocardiograms to screen for CDM. However, it is challenging to predict who will develop CDM before it manifests as overt cardiac dysfunction. We

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sought to determine whether the trajectory of change in serial echocardiogram parameters is associated with CDM. **Methods:** We performed a multicenter case-control study. CDM cases (≥1y survival from end of cancer therapy; fractional shortening (FS) ≤28% or ejection fraction (EF) ≤50% on ≥2 occasions) were matched to controls (FS ≥30%, EF ≥55%, not on cardiac medications) by cumulative anthracycline dose, chest radiation, follow-up duration, and age at cancer diagnosis. Echocardiograms were submitted to a core lab and analyzed using a vendor-neutral software analysis package. We examined the trajectory of 2D, M-mode, and Doppler tissue imaging derived parameters using linear mixed models, adjusted for time prior to CDM (or matched time for controls) and case/control status with an interaction to compare changes over time between groups. **Results:** We identified 48 case-control pairs from 5 centers (35 vs 42% female; mean age at cancer diagnosis 8.1 vs 7.2 y; median anthracycline dose 240 vs 245 mg/m2; 44 vs 44% radiation to the heart; mean follow-up duration 10.3 vs 9.9 y). Analysis of 327 studies found that changes in FS (2D and M-mode), biplane EF, and spectral-Doppler derived left ventricular myocardial performance indices (LV-MPI) were significantly different between cases vs controls. This relationship held true even when studies within 2 years of CDM diagnosis were excluded from the analysis (Table). If studies within 3 years were removed, only FS (2D) and LV-MPI were significantly different. Differences in 2D wall thickness-dimension ratio only became apparent late. However, the ratio's trajectory was significantly different among cases vs controls (interaction p=0.018). LV diastolic function (mitral and septal E/E') did not vary among cases vs controls. **Conclusions:** In this study of childhood cancer survivors, we observed a decline in standard echocardiographic parameters up to 3 yrs prior to CDM diagnosis, suggesting that high-risk survivors can be identified prior to the onset of clinical symptoms or an abnormal echocardiogram.

TABLE. Statistical differences (p-values) in left ventricular systolic function and geometry between cardiomyopathy (CDM) cases and controls across varying time intervals.

Parameter	All time points, inclusive of CDM diagnosis	If times points prior to cardiomyopathy (CDM) diagnosis are excluded				Interaction of case vs control status with time, all time points
		Exclude CDM diagnosis time point	Exclude time points within 1 yr of CDM	Exclude time points within 2 yrs of CDM	Exclude time points within 3 yrs of CDM	
FS% (2-D)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*0.024*	*<0.001*
FS% (M-mode)	*<0.001*	*<0.001*	*0.001*	*0.008*	0.239	*0.003*
Biplane EF%	*<0.001*	*<0.001*	*<0.001*	*0.015*	0.310	*<0.001*
Thickness-dimension ratio (2D)	*0.020*	*0.041*	0.892	0.776	0.583	*0.018*
Thickness-dimension ratio (M-mode)	0.714	0.506	0.347	0.306	0.141	*0.004*
MPI (LV)	*<0.001*	*<0.001*	*0.001*	*0.006*	*0.036*	0.152
MPI (DTI)	*0.006*	0.094	*0.042*	0.087	0.644	0.395

OA-06

Disordered Intraventricular Vortex Formation and Increased Energy Loss in Transplanted Hearts is Noted in the Absence of Active Rejection

Jonathan D. Nyce, Santosh C. Uppu, H. Helen Ko, Jen-Li Yau, Shubhika Srivastava. Kravis Children's Hospital at Mount Sinai, New York City, NY

Background: Vector flow mapping (VFM) is a novel technique that allows for insight into blood-myocardial interactions. Vortex formation during diastole reduces energy loss (EL) and results in effectively organized systolic ejection. We hypothesized that transplanted hearts (OHT) would have higher EL in spite of normal ejection fraction (EF) even in the absence of rejection. **Methods:** 26 subjects, 13 OHT and 13 age-matched normals, with normal EF who were imaged using Hitachi ProSound F75 Premier CV were included. None of the OHT subjects included had rejection. EL in diastole and systole were obtained offline by VFM analysis of apical long-axis images (Figure 1). Tissue Doppler (TDI) measures of systolic (s') and diastolic (e', a', E/e') function were recorded along with the derived left ventricular volumes and EF. analyses was performed between groups.

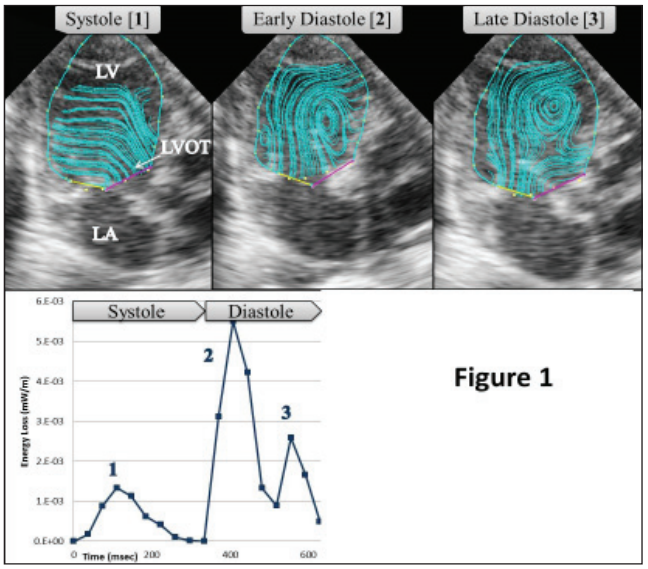

Figure 1

Results: OHT subjects were 14.7 ± 4.8 yrs compared to 14.17 ± 4.4 yrs for normals; age from transplant was 7.43 ± 7.0 yrs. OHT had lower, but normal EF compared to matched controls (58.3 ± 3.2% vs. 63 ± 4.5%; p=0.01). Resting heart rate was higher in OHT (90 ± 8.2/min vs. 74 ± 12/min; p<0.05). All TDI indices were lower in OHT (Figure 2). BSA-indexed systolic and diastolic EL were significantly higher in OHT (p<0.001) and remained consistently higher across all ages (Figure 3).

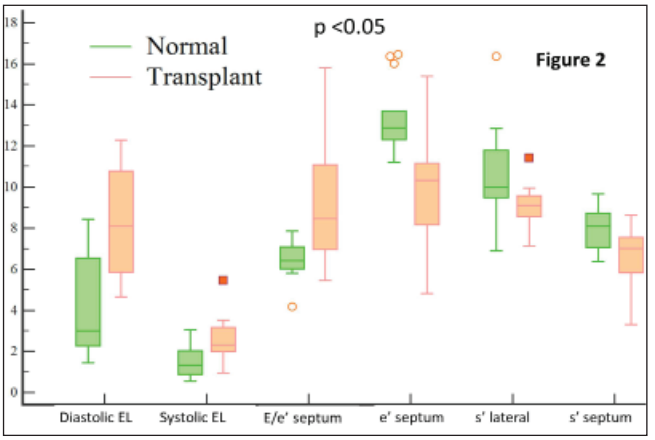

Figure 2

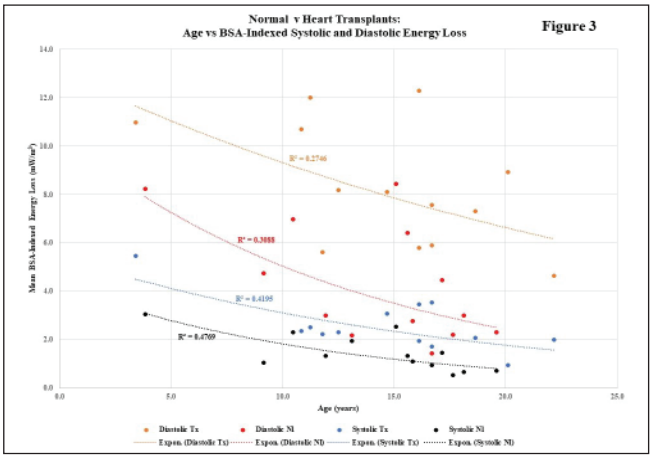

Figure 3

Conclusion: Left ventricular filling and ejection had increased EL in OHT as compared to age-matched normals despite normal EF. Subclinical dysfunction and a higher resting heart rate may increase shearing forces thus resulting in increased EL in OHT patients. VFM provides a novel insight into ventricular and fluid mechanics of OHT.

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OA-07

Challenges with LV Functional Parameters: The Pediatric Heart Network Normal Echocardiogram Database

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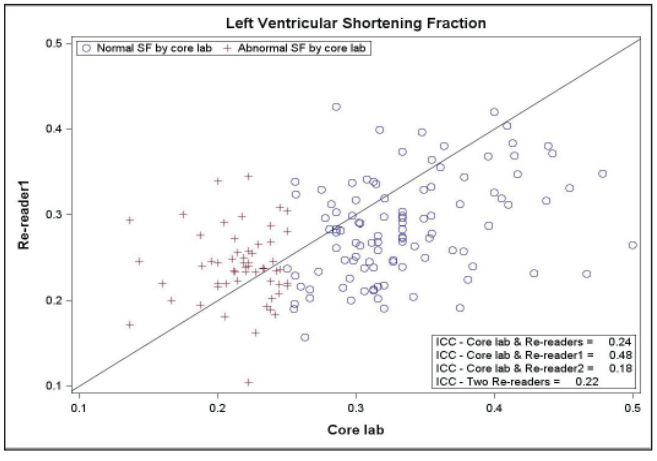
Background: The reliability of left ventricular (LV) systolic functional indices calculated from blinded echo measures of LV size has not been tested in a large cohort of normal children. **Methods:** The Pediatric Heart Network Normal Echocardiogram Database collected normal clinical echo studies from healthy children ≤18 years old distributed equally by age, gender, and race categories. A core lab used 2-dimensional (2D) echo to measure LV dimensions and area from which a separate Data Coordinating Center calculated LV volumes and systolic functional indices. To evaluate interobserver variability, 2 independent pediatric echo experts measured LV dimensions and area without immediate calculation of LV systolic functional indices (blinded measures) for a subset of the studies. **Results:** Of 3215 subjects with measurable images, 552 (17%) had a calculated LV shortening fraction (SF) <25% and/or LV ejection fraction (EF) <50% using core lab 2D measures; the 552 subjects were significantly younger and smaller than the 2663 with normal values. Reliability varied when comparing the core lab and independent reader measures for 80 subjects with and 80 subjects without abnormal SF/EF values. For individual LV size parameters, the intraclass correlation coefficient (ICC) was high (0.81-0.99), indicating low variability between the core lab and the readers. The ICCs were lower for SF (0.24) (Figure) and EF (0.56). Of those with an abnormal SF calculated from core lab measures, 71% were also classified as abnormal by at least one reader; of those with normal SF from core lab measures, 33% were also independently classified as abnormal. **Conclusions:** Although measures of LV size show good reproducibility, calculated LV functional indices from blinded measures reveal significant variability such that abnormal SF/EF values can be associated with normal echo studies despite qualitatively normal systolic function. This suggests that, in clinical practice, abnormal SF/EF values usually result in repeat measures of LV size to match the subjective assessment of function. Abnormal values are more prevalent in younger, smaller children, likely due to agitation-limited imaging and measure error. This study highlights the potential value of automated endocardial tracking to decrease variability for measures of LV size and function.



OA-08

Persistence of Right Ventricular Dysfunction and Morphometry in Preterm Infants through One Year of Age: Cardiac Phenotype of Prematurity

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Background: Prematurity impacts myocardial development that may determine long-term outcomes. The objective of this study was to test the hypothesis that preterm neonates develop right ventricle (RV) dysfunction and adaptive remodeling by one month of age that persists through one year corrected age. **Methods:** In a prospective cohort study of 80 preterm- (< 29 weeks gestation) and 50 age- and weight- matched term- born infants, echocardiogram measures of RV function [free wall longitudinal strain (LS), systolic strain rate (LSRs), segmental LS (SLS) of the regional RV free wall (RVFW), tricuspid annular plane systolic excursion (TAPSE), and fractional area of change, FAC)] and RV morphology (systolic and diastolic areas and dimensions from the apical 4 chamber view) were assessed and compared at one month and one year of age. Sub-analyses were performed in preterm-born infants with chronic lung disease (CLD, n=48, 59%), defined by the need for any respiratory support at 36 weeks postmenstrual age. Data analysis included adjustment for gestational age at birth, gender, and heart rate. **Results:** In both term- and preterm-born infants, the measures of RV function and morphology increased from 1 month to 1 year of age ($p < 0.01$ for all) , but the magnitudes of RV function measures were lower in preterm-born infants at each time period ($p < 0.01$ for all), irrespective of the degree of lung disease. (Figure A) The magnitude of LSRs declined over time in preterm-born infants with CLD [-1.8 (-1.6, -2.1) vs. -1.6 (-1.5, -1.9), p=0.02, Figure B). RV areas and dimensions were larger in preterm infants by one year of age period ($p < 0.01$ for all, except long length, Table) A significant base-to-apex (highest-to-lowest) SLS gradient ($p < 0.01$) existed in all infants at 1 month and persisted to 1 year of age, but the magnitudes were lower in preterm-born infants at each time period (Figure C). Unique to preterm-born infants with CLD, measures of RV function were decreased and RV morphometric (basal and mid-ventricular dimension) increased at 1 month of age and persisted to 1 year of age, ($p < 0.01$ for all measures, Table) **Conclusions:** Preterm infant exhibits abnormal RV function and morphometric at one month of age that persists to one year of age when compared to term-born infants. CLD appears to leave a further negative impact on RV performance.

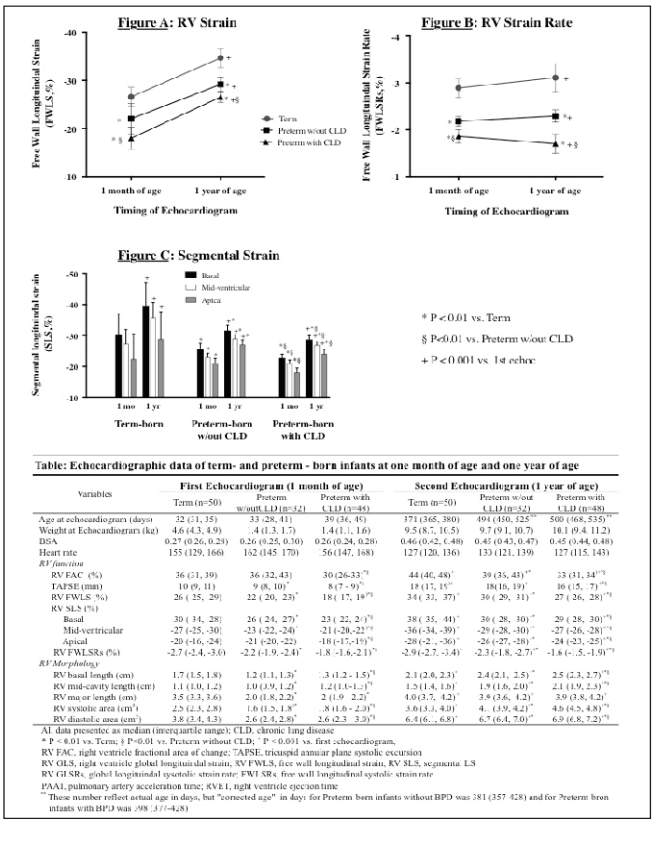

Table: Echocardiographic data of term- and preterm - born infants at one month of age and one year of age

Variables	First Echocardiogram (1 month of age)			Second Echocardiogram (1 year of age)		
	Term (n=50)	Preterm w/out CLD (n=32)	Preterm with CLD (n=48)	Term (n=50)	Preterm w/out CLD (n=32)	Preterm with CLD (n=48)
Age at echocardiogram (days)	32 (31, 35)	33 (28, 41)	39 (34, 45)	371 (365, 380)	494 (450, 525)*†	500 (468, 535)*†
Weight at Echocardiogram (kg)	4.6 (4.3, 4.9)	4.4 (4.3, 4.7)	4.4 (4.1, 4.6)	9.5 (8.7, 10.5)	9.7 (9.1, 10.7)	10.1 (9.4, 11.2)
BSA	0.27 (0.26, 0.29)	0.26 (0.25, 0.30)	0.26 (0.24, 0.28)	0.46 (0.42, 0.48)	0.45 (0.43, 0.47)	0.45 (0.44, 0.48)
Heart rate	155 (129, 166)	162 (145, 170)	156 (147, 168)	127 (120, 136)	133 (121, 139)	127 (115, 143)
RV function						
RV FAC (%)	36 (31, 39)	36 (32, 43)	30 (26-33)*§	44 (40, 48)†	39 (35, 43)*†	33 (31, 34)*†§
TAPSE (mm)	10 (9, 11)	9 (8, 10)*	8 (7 - 9)*§	18 (17, 19)*†	18(16, 19)†	16 (15, 17)*†§
RV FWLS (%)	26 (25, 29)	22 (20, 23)*	18 (17, 19*§	34 (33, 37)†	30 (29, 31)*†	27 (26, 28)*†§
RV SLS (%)						
Basal	30 (34, 28)	26 (24, 27)*	23 (22, 23)*§	38 (35, 41)†	30 (28, 30)*†	29 (28, 30)*§
Mid-ventricular	-27 (-25, -30)	-23 (-22, -24)*	-21 (-20, -22)*§	-36 (-34, -39)†	-29 (-28, -30)*†	-27 (-26, -28)*†§
Apical	-20 (-16, -24)	-21 (-20, -22)	-18 (-17,-19)*§	-28 (-2 , -36)†	-26 (-27, -28)*†	-24 (-23, -25)*†§
RV FWLSRs (%)	-2.7 (-2.4, -3.0)	-2.2 (-1.9, -2.4)*	-1.8 (-1.6,-2.1)*§	-2.9 (-2.7, -3.4)	-2.3 (-1.8, -2.7)*†	-1.8 (-.5, -1.9)*†§
RV Morphology						
RV basal length (cm)	1.7 (1.5, 1.8)	1.2 (1.1, 1.3)*	1.3 (1.2- 1.5)*§	2.1 (2.0, 2.3)†	2.4 (2.1, 2.5)*†	2.5 (2.3, 2.7)*†
RV mid-cavity length (cm)	1.1 (1.0, 1.2)	1.0 (0.9, 1.2)*	1.2 (1.1-1.3)*§	1.5 (1.4, 1.6)†	1.9 (1.6, 2.0)*†	2.1 (1.9, 2.3)*†
RV major length (cm)	3.5 (3.3, 3.6)	2.0 (1.8, 2.2)*	2 (1.9 2.2)*	4.0 (3.7, 4.2)†	3.9 (3.6, 4.2)†	3.9 (3.8, 4.2)†
RV systolic area (cm^2)	2.5 (2.3, 2.8)	1.6 (1.5, 1.8)*	.8 (1.6 - 2.3)*§	5.6 (5.3, 6.0)†	4. (3.9, 4.2)*	4.6 (4.5, 4.8)*†
RV diastolic area (cm^2)	3.8 (3.4, 4.3)	2.6 (2.4, 2.8)*	2.6 (2.3 3.3)*§	6.4 (6. , 6.8)†	6.7 (6.4, 7.0)*†	6.9 (6.8, 7.2)*†

Al data presentec as median (interquartile range); CLD, chronic lung disease
* P < 0.01 vs. Term; § P<0.01 vs. Preterm without CLD; † P < 0.001 vs. first echocardiogram.
RV FAC, right ventricle fractional area of change; TAPSE, tricuspid annular plane systolic excursion
RV GLS, right ventricle global longitudinal strain; RV FWLS, free wall longitudinal strain; RV SLS, segmenta LS
RV GLSRs, global longitudinal systolic strain rate; FWLSRs free wall longitudinal systolic strain rate
PAAI, pulmonary artery acceleration time; RVE1, right ventricle ejection time
These number reflect actual age in days, but "corrected age" in days for Preterm born infants without BPD was 381 (357, 428) and for Preterm bron infants with BPD was 398 (371-428)

Oral Abstracts (OA)

Saturday, June 23, 2018 — Tuesday, June 26, 2018

OA-09

Evaluation of Left Ventricular Outflow Gradients During Staged Exercise Stress Echocardiography Helps Differentiate Patients with Hypertrophic Cardiomyopathy from Athletes and Normal Subjects

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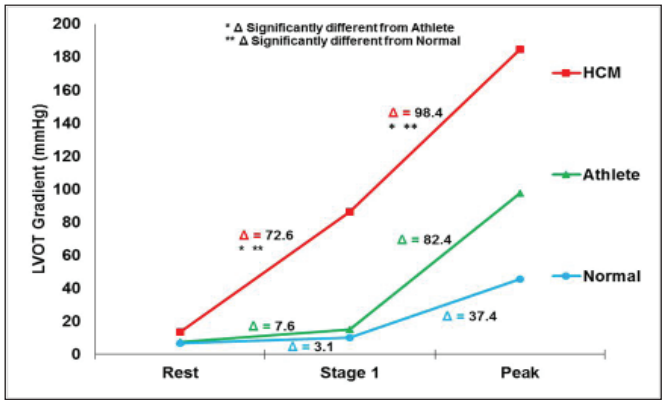
Background: Elevated left ventricular outflow tract (LVOT) Doppler gradients during peak exercise can occur in patients with hypertrophic cardiomyopathy (HCM) as well as in athletes and normal subjects. Our staged upright exercise protocol calls for detailed two-dimensional and Doppler imaging at rest and during each stage of exercise until peak exercise, allowing us to evaluate the mechanism of LVOT obstruction at each stage. We sought to determine whether this staged approach helps differentiate HCM patients from athletes and normal subjects who develop elevated gradients with exercise. **Methods:** We reviewed records of patients < 22 years who underwent a stress echocardiogram from Jan 2009 - Oct 2017 at our center. We identified all patients with gene-positive HCM, those diagnosed with athlete's heart, and normal subjects. We then selected subjects with no significant LVOT gradient at rest while supine who subsequently developed a LVOT peak gradient of at least 25 mmHg at peak exercise. We measured LVOT peak gradient, velocity time integral (VTI), acceleration time (AT), and deceleration time (DT) at rest while supine, at submaximal stages, and at peak exercise. T-test, ANOVA, and Tukey-Kranmer method were used for statistical analysis with p-value set at < 0.05. **Results:** Compared to athletes (n = 10) and normal subjects (n = 10), respectively, HCM patients (n = 10) had a difference in LVOT peak gradients at rest (p = 0.019; p = 0.007), stage 1 of exercise (p = 0.002; p <0.001), and peak exercise (p = 0.051; 0.003) [Figure], as well as a difference in the change in LVOT peak gradient from rest to stage 1 (p = 0.016; p = 0.015) and from rest to peak (p = 0.038; p <0.001). The VTI of the LVOT doppler in HCM patients was different at rest, stage 1 of exercise, and peak exercise compared to athletes and normal patients. There was a statistically significant difference in the AT/DT in HCM patients compared to normal patients at rest, stage 1, and peak exercise but only at rest when comparing HCM patients to athletes. **Conclusion:** HCM patients who develop elevated LVOT gradients at peak exercise typically manifest early obstruction in the submaximal stages of exercise, which helps to differentiate them from athletes and normal subjects. This supports the use of staged exercise stress echocardiography in these patients.



OA-10

Serial Deformation Assessment Identifies Hypoplastic Left Heart Syndrome Infants at Risk for Cardiac Mortality and Morbidity: A Pilot Study

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Background: Poor right ventricular systolic function is associated with morbidity and mortality in children with hypoplastic left heart syndrome. Myocardial deformation parameters derived from speckle-tracking echocardiography are highly reproducible and correlate with MRI-derived ejection fraction. The use of serial deformation assessments to risk-stratify these infants has not been well described. **Methods:** Prospective echocardiography was performed in infants with hypoplastic left heart syndrome prior to surgical palliation and <2 weeks of age (time point (TP) 1), after Norwood and <1 month of life (TP2), >1 month and prior to Glenn (TP3), and after Glenn and <6 month (TP4). Offline analysis was done using GE EchoPAC. Measurements of right ventricular function from standard apical and basal views included global longitudinal strain (GLS) and strain rate (Sr), basal circumferential strain (CS) and Sr, fractional area change, and TAPSE. Echocardiograms from patients who experienced a poor outcome (defined as death, transplant, listing for transplant, or ≥ moderate right ventricular dysfunction by 6 months of age) were compared to echocardiograms in survivors at each time point using Wilcoxon rank sum test. Receiver operating curve analyses were created. Those who were not Norwood candidates or who died from a non-cardiac cause were excluded. **Results:** 31 patients were included (7 with poor outcome). No differences in echo measurements were noted on the initial echo (TP1). Beyond 2 weeks of life and prior to Glenn, there were significant differences in all echocardiographic measures except TAPSE (see table). By receiver operator curve analysis, a pre-Glenn GLS of > -13% (during TP3) was highly sensitive and specific for poor outcome (area under curve [AUC] 0.97, p<0.01). Other significant thresholds included: GLSr > -1 %/sec at TP3 (AUC 1.0, p<0.01), basal CS at TP2 and TP3 (> -12.5%, AUC 0.88, p=0.02 and > -10.8% AUC 0.87, p=0.02), basal CSr at TP3 (> -0.85%/sec, AUC 0.88, p=0.02), and fractional area change at TP3 <35% (AUC 0.94, p<0.01). **Conclusion:** In this pilot study, interstage longitudinal and circumferential strain indices were worse in hypoplastic left heart syndrome infants who experienced a poor outcome. Further analysis with larger cohorts is needed to confirm their predictive utility.

Table. Serial echocardiographic assessments of right ventricular function in infants with hypoplastic left heart syndrome and association with adverse outcome*

	<2 weeks (TP1)	After Norwood-1 month (TP2)	>1 month – pre-Glenn (TP3)	Post Glenn- 6 month (TP4)
GLS (%)				
Survivor	-18.1±3.1 (n=20)	-17.6±2.4 (n=21)	-17.4±3.4 (n=16)	-13.1±3.4 (n=15)
Outcome	-16.7 ±2.6 (n=5)	-14.6±3.1 (n=7)	-10 ± 2.5 (n=5)	-12± 4.5 (n=6)
	p=0.61	**p=0.04**	**p<0.01**	p=0.39
GLSr (%/sec)				
Survivor	-1.5 ± 0.3 (n=20)	-1.3 ± 0.2 (n=19)	-1.2 ± 0.2 (n=16)	-1.0 ± 0.2 (n=15)
Outcome	-1.4 ± 0.3 (n=5)	-1.0 ± 0.2 (n=7)	-0.6 ± 0.1 (n=5)	-0.8 ± 0.3 (n=6)
	p=0.32	**p=0.02**	**p <0.01**	p=0.14
Basal CS (%)				
Survivor	-9.8 ± 3.0 (n=20)	-14.7±4.5 (n=21)	-12.5±3.3 (n=16)	-9.3 ± 2.9 (n=15)
Outcome	-7.7 ± 3.2 (n=5)	-9.9 ± 2.7 (n=7)	-7.0 ± 3.2 (n=5)	-7.9 ± 3.5 (n=6)
	p=0.17	**p<0.01**	**p=0.02**	p=0.31
Basal CSr (%/sec)				
Survivor	-1.1 ± 0.3 (n=20)	-1.3 ± 0.3 (n=21)	-0.9 ± 0.2 (n=16)	-0.9 ± 0.1 (n=15)
Outcome	-1 ± 0.1 (n=5)	-1.0 ± 0.2 (n=7)	-0.7 ± 0.1 (n=5)	-0.7 ± 0.2 (n=6)
	p=0.32	**p=0.02**	**p<0.01**	**p<0.01**
FAC (%)				
Survivor	44 ± 9 (n=20)	43 ± 11 (n=21)	42 ± 8 (n=16)	37 ± 6 (n=15)
Outcome	36 ± 10 (n=5)	35 ± 3 (n=7)	29 ± 5 (n=5)	33 ± 10 (n=6)
	p=0.09	**p<0.01**	**p<0.01**	p=0.41
TAPSE (mm)				
Survivor	7.8 ± 1.8 (n=20)	5.0 ± 1.2 (n=21)	6.1 ± 1.3 (n=16)	5.2 ± 0.9 (n=15)
Outcome	8.3 ± 1.9 (n=5)	5.8 ± 2.7 (n=7)	5.6 ± 1.7 (n=5)	5.0 ± 1.0 (n=6)
	p=0.63	p=0.65	p=0.53	p=0.53

*Adverse outcome defined as as death, transplant, listing for transplant, or ≥ moderate right ventricular dysfunction by 6 months of age
GLS: global longitudinal strain; GLSr: global longitudinal strain rate; CS: circumferential strain; CSr: circumferential strain rate; FAC: fractional area change; TAPSE: tricuspid annular plane systolic excursion

OA-11

Late Gestation Predictors of a Postnatal Biventricular Circulation after Fetal Aortic Valvuloplasty

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Background: Fetal aortic valvuloplasty (FAV) in mid-gestation has shown promise in averting progression to hypoplastic left heart syndrome in fetuses with severe aortic stenosis. After a technically successful FAV, predicting which fetuses will achieve a biventricular circulation after birth has been challenging. Identifying predictors of a postnatal biventricular circulation on late gestation fetal echocardiography will improve parental counseling and inform delivery planning. **Methods:** Patients who underwent a FAV, had a late gestation fetal echo available, and survived to neonatal discharge were included (2000-2017, n=107). Paired testing methods were utilized to identify third trimester fetal echo anatomic and physiologic parameters associated with postnatal biventricular circulation. The changes in several of these measures through gestation (from pre-FAV to third trimester) were also analyzed as potential predictors. **Results:** In univariate analysis (table), several anatomic parameters were associated with a postnatal biventricular circulation including a higher diameter z-score for the aortic valve, ascending aorta, mitral valve, and left ventricular (LV) long axis. Predictive physiologic parameters included LV ejection fraction, mitral valve inflow time, anterograde flow around the aortic arch, and normalization of flow across the foramen ovale (from abnormal left-to-right flow to bidirectional or right-to-left flow). In multivariable analysis (table), independent predictors of a biventricular circulation included LV long axis z-score, anterograde aortic arch flow, and normalization of PFO flow direction. Improved left heart growth through gestation was associated with biventricular circulation, specifically a larger increase in z-scores of the aortic valve (-0.8 {-1.8, -0.2} vs 0.3 {-1.0, 0.7}, p=0.003), LV long axis (-3.4 {-4.2, -1.5} vs -1.6 {-2.3, -0.7}, p<0.001), LV end diastolic dimension (-4.4 {-6.2, -2.3} vs -2.6 {-4.7, -0.4}, p=0.002), and LV end diastolic volume (-4.2 {-5.7, -2.4} vs -3.2 {-4.8, -1.4}, p=0.01). **Conclusion:** Late gestation predictors of a postnatal biventricular circulation after FAV include LV long axis z-score, anterograde flow around the aortic arch, and normalization of flow across the foramen ovale.

Oral Abstracts (OA)

Saturday, June 23, 2018 — Tuesday, June 26, 2018

Analysis of Third Trimester Echocardiographic Parameters Associated with Biventricular Circulation				
	Single Ventricle (n=46)	**Biventricular (n=50)**	**Odds ratio (95% CI)**	**p-value**
Univariate Analysis				
Gestational age at FAV	23.50 (22.0, 25.21)	25.64 (23.0, 27.64)		0.002
Male gender	37 (80.4%)	39 (78.0%)	0.93 (0.59, 1.47)	0.806
AoV diameter z-score	-3.42 (-4.20, -2.7)	-2.82 (-3.11, -1.94)		<0.001
AscAo diameter z-score	-1.02 (-1.65, 0.02)	0.70 (-0.63, 1.96)		<0.001
LV long axis z-score	-2.42 (-3.23, -1.15)	-0.8 (-1.48, 0.46)		<0.001
LVEDD z-score	-1.22 (-2.35, 0.20)	-0.05 (-1.94, 1.40)		0.06
LVEDV z-score	-2.92 (-3.60, -1.06)	-0.70 (-2.08, 0.86)		0.001
LV sphericity	0.67 (0.58, 0.76)	0.60 (0.47, 0.74)		0.079
LV ejection fraction	36.8 (25.92, 44.98)	48.65 (36.05, 57.88)		0.001
MV diameter z-score	-2.97 (-3.77, -2.02)	-1.84 (-2.95, -0.80)		0.001
MV inflow time (msec)	152 (113, 174)	184 (158, 201)		0.006
Aortic jet width	3.4 (2.60, 4.0)	3.8 (3.50, 4.50)		0.033
LV pressure estimate	68.86 (51.64, 77.72)	72.71 (56.0, 87.14)		0.262
LV dysfunction (> moderate)	39 (86.7%)	24 (48%)	7.04 (2.53, 19.61)	<0.001
Antegrade aortic arch flow	7 (15.6%)	26 (52%)	5.88 (2.21, 15.65)	<0.001
PFO flow (left-to-right)	33 (82.5%)	19 (43.2%)	6.21 (2.26, 16.95)	<0.001
Multivariate Analysis				
AscAo diameter z-score			0.98 (0.59, 1.62)	0.93
LV long axis z-score			4.84 (2.01, 11.62)	<0.001
LV ejection fraction			1.04 (0.98, 1.10)	0.16
MV diameter z-score			1.00 (0.64, 1.57)	0.992
Antegrade aortic arch flow			10.94 (1.46, 82.14)	0.02
PFO flow (left-to-right)			8.27 (1.59, 43.03)	0.01

OA-12

Echocardiographic Surveillance in Children after Tetralogy of Fallot Repair: Adherence to guidelines?

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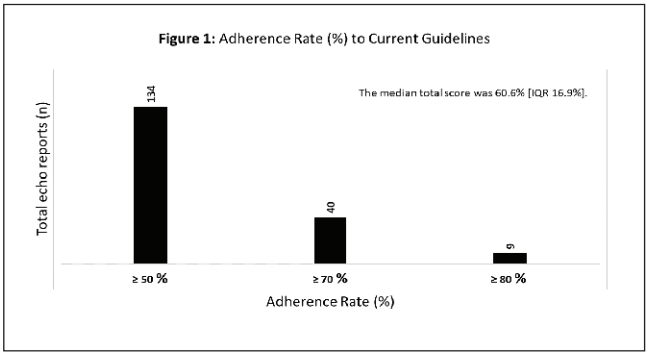
Background: Longitudinal clinical surveillance by transthoracic echocardiography (TTE) is an established practice in children with repaired tetralogy of Fallot (TOF). The Multimodality Non-Invasive Imaging Guidelines by the American Society of Echocardiography recommends a list of major reporting elements with several subcomponents that should be addressed during routine TTE in this population. In this multicenter study, we sought to determine the adherence to these recommendations. **Methods:** This was a multi-center retrospective review of echocardiographic (echo) reports of children ≤ 10 years of age who have had complete TOF repair. We included 10 patients from each of the 8 participating centers (n = 80) and scored 2 outpatient follow-up echo reports performed between March 2014-March 2016 for each patient. The total score was based on the completeness of the echo reporting elements and subcomponents derived from the guidelines (Table 1). **Results:** We reviewed and scored 160 echo reports on 80 patients. The mean age at the time of complete surgical repair was 6.8 ± 10.2 months and the mean age at the time of the first echo report was 4.1 ± 2.9 years. The median total score was 60.6% [IQR 16.9%]. Of the 160 reports, 9 (7%) were ≥ 80% adherent, 40 (25%) were ≥ 70% adherent, and 134 (83.7%) were ≥ 50% adherent (Figure 1). Quantitative measurements of right ventricular size and function and the branch pulmonary arteries were the least likely to be reported. There was a positive correlation between the total score and age as well as body surface area (p=0.0072 and 0.0071). **Conclusion:** The overall adherence to the most recent published imaging guidelines for surveillance of children with repaired TOF patients is low. Further studies are needed to explore the barriers to adherence to guidelines and whether adherence is associated with clinical outcomes.

Table 1. Echocardiographic Reporting Checklist for Children Undergoing Surveillance after Repaired TOF

Reporting Elements and Subcomponents[1]	
Section 1	Right ventricular outflow tract and main pulmonary artery - Dimensions, peak and mean Doppler gradients
Section 2	Degree of pulmonary valve regurgitation - Quantification by color and spectral Doppler
Section 3	Branch pulmonary arteries - Dimensions, mention of presence or absence of obstruction
Section 4	Degree and mechanism of tricuspid valve regurgitation
Section 5	Right ventricular pressure - Tricuspid valve regurgitation velocity or trans-ventricular septal gradient, septal configuration
Section 6	Right ventricular size and volume load - Tricuspid valve annulus diameter, diastolic septal flattening, quantitative measurements of right ventricular size
Section 7	Right ventricular function - Quantitative measurements of right ventricular function
Section 8	Residual ventricular septal defects
Section 9	Residual atrial septal defects
Section 10	Aortic dimensions - Annulus, root and or ascending aorta
Section 11	Aortic valve regurgitation
Section 12	Left ventricular size and function - Quantitative measurement of systolic function

Modified from Valente AM, Cook S, Festa P, et al. Multimodality imaging guidelines for patients with repaired tetralogy of fallot: a report from the American society of Echocardiography: developed in collaboration with the Society for Cardiovascular Magnetic Resonance and the Society for Pediatric Radiology. *J Am Soc Echocardiogr.* 2014;27(2):111-141.



OA-13

Discordance in Left Ventricular Cavity Dilation by Vasodilation-Positron Emission Tomography and Stress-Echocardiography in Hypertrophic Cardiomyopathy Patients

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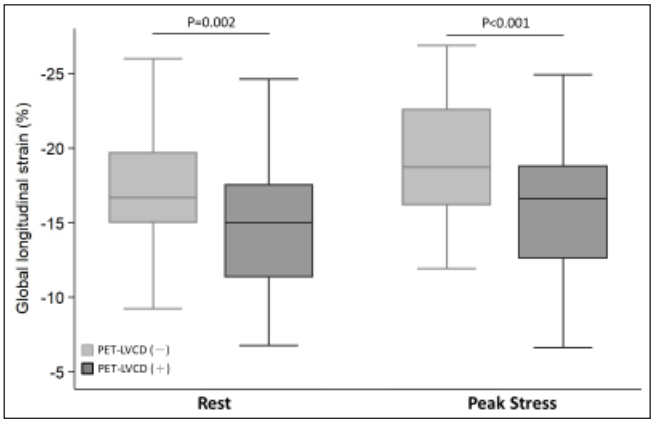
Background Transient left ventricular cavity dilatation (LVCD) following vasodilator/exercise, reflects global ischemia in patients with severe epicardial coronary artery disease (CAD). Vasodilator-induced LVCD is also seen in patients with hypertrophic cardiomyopathy (HCM) who have severe microvascular dysfunction (in the absence of CAD). But it is unknown whether HCM patients who develop PET-LVCD following vasodilator also develop LVCD by ECHO, following exercise-stress. **Methods** We retrospectively studied 108 HCM patients who underwent both 13NH3-PET and exercise-ECHO. Myocardial blood flow, myocardial flow reserve, left ventricular (LV) volumes and ejection fraction (LVEF) were quantified using PET, at rest and following vasodilator stress. LV volumes, LVEF and global longitudinal strain, were measured by ECHO, at rest and following exercise-stress. Cardiac magnetic resonance (CMR) imaging was also performed to measure LV mass and late gadolinium enhancement (LGE). **Results** Transient PET-LVCD following vasodilator-stress was evident in 51% (n=55) of HCM patients. Patients with PET-LVCD had higher LV mass index and higher prevalence of LGE by CMR, Notably, patients with PET-LVCD had no evidence of LVCD by ECHO. Stress echocardiography revealed similar end-diastolic volume remained at rest (76 ± 18 vs. 75 ± 15 ml, p=0.7, for patients without and with PET-LVCD), and at peak exercise (p=0.7). There was significant reduction in end-systolic volume at peak exercise, resulting in increase in LVEF. Nevertheless, the PET-LVCD group had greater impairment of global longitudinal strain at rest/exercise-stress than the non-PET-LVCD group (rest: -17 ± 3 vs -15 ± 4%, p = 0.002, and stress: -19 ± 4 vs. -16 ± 4%, p<0.001) (Figure). Patients with PET-LVCD had lower global myocardial flow reserve, lower PET-LVEF, higher summed difference scores, and higher incidence of ischemic ST-T changes with vasodilator-stress. **Conclusions** PET-LVCD reflects a more severe cardiac HCM phenotype, greater degree of myopathy and microvascular dysfunction. Transmural steal from the subendocardium to subepicardium due to lower subendocardial MFR following vasodilator stress, and exercise-induced cardiac beta-receptor stimulation (by sympathetic activation) could underlie lack of ECHO-LVCD in HCM patients with PET-LVCD.

Oral Abstracts (OA)

Saturday, June 23, 2018 — Tuesday, June 26, 2018



OA-14

The Relationship Between Left Ventricular Geometry and Invasive Hemodynamics in Pediatric Pulmonary Hypertension

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Background: Septal flattening is used as an assumption of elevated pulmonary pressures in pediatric pulmonary hypertension (PH), especially when methods to quantify pressures are absent. However, quantification of septal flattening, and the relationship between right (RV) and left ventricular (LV) shape, have not been fully evaluated with concurrent hemodynamics by simultaneous cardiac catheterization and echocardiography in pediatric PH. We hypothesized increased eccentricity index (EI), including a novel maximum EI, and RV:LV diameter ratio with worsening cardiopulmonary hemodynamics in pediatric PH. **Methods:** At 2 institutions, a prospective study was conducted in 80 children and young adults undergoing simultaneous echocardiography and cardiac catheterization for PH evaluation. We excluded patients with left-sided obstruction, systemic hypertension, pacemaker, heart transplant or single-ventricle physiology. By 2-D echocardiography from mid-papillary parasternal short-axis views, end-systolic, end-diastolic & maximum EI (peak flattening, including post-systolic septal flattening) were assessed, as were end-systolic and end-diastolic RV:LV diameter ratio. Results were compared to 58 age-, gender-, and institution-matched healthy controls. **Results:** Compared to controls, PH patients had increased diastolic, systolic and maximum EI, and systolic and diastolic RV:LV diameter ratio (Table 1). Maximum EI correlated better with hemodynamics than systolic or diastolic EI, or RV:LV diameter ratio (Table 1). Receiver operator characteristic curves demonstrated the greatest area under the curve for maximum EI, which was able to best identify half-systemic, ¾-systemic, and systemic PH (Figure 1). **Conclusion:** Though EI and RV:LV diameter ratios are abnormal in PH and demonstrate moderate correlation with invasive hemodynamics, maximum EI (which detects the early post-systolic septal flattening often seen in PH) demonstrates the best correlations and ability to detect clinically important PH.

Table 1. Left Ventricular Geometry in Pulmonary Hypertension and the Relationship with Invasive Hemodynamics

	PH versus Controls			Geometric Measures versus Hemodynamics							
Echocardiographic Measure	PH (N=80)	Controls (N=58)	P value	MPAP	P value	MPAP/MAP	P value	PVRi	P value	PVR/SVR	P value
End-Diastolic Eccentricity Index	1.23 ± 0.23	1.00 ± 0.07	<0.0001	0.52 (0.33-0.67)	<0.0001	0.52 (0.32-0.67)	<0.0001	0.68 (0.54-0.79)	<0.0001	0.51 (0.32-0.67)	<0.0001
End-Systolic Eccentricity Index	1.36 ± 0.37	0.99 ± 0.07	<0.0001	0.60 (0.43-0.73)	<0.0001	0.64 (0.48-0.76)	<0.0001	0.63 (0.47-0.75)	<0.0001	0.62 (0.45-0.75)	<0.0001
Maximum Eccentricity Index	1.55 ± 0.49	1.04 ± 0.08	<0.0001	0.63 (0.45-0.76)	<0.0001	0.71 (0.56-0.82)	<0.0001	0.63 (0.45-0.76)	<0.0001	0.70 (0.54-0.81)	<0.0001
End-Diastolic RV:LV Ratio	0.58 ± 0.21	0.33 ± 0.12	<0.0001	0.51 (0.29-0.67)	<0.0001	0.56 (0.36-0.72)	<0.0001	0.60 (0.41-0.74)	<0.0001	0.57 (0.38-0.72)	<0.0001
End-Systolic RV:LV Ratio	0.95 ± 0.49	0.49 ± 0.17	<0.0001	0.61 (0.42-0.75)	<0.0001	0.68 (0.51-0.80)	<0.0001	0.59 (0.40-0.73)	<0.0001	0.68 (0.52-0.80)	<0.0001

Presented as mean ± standard deviation and correlation Coefficient (95% Confidence Interval). PH indicates pulmonary hypertension; RV, right ventricle; LV, left ventricle.

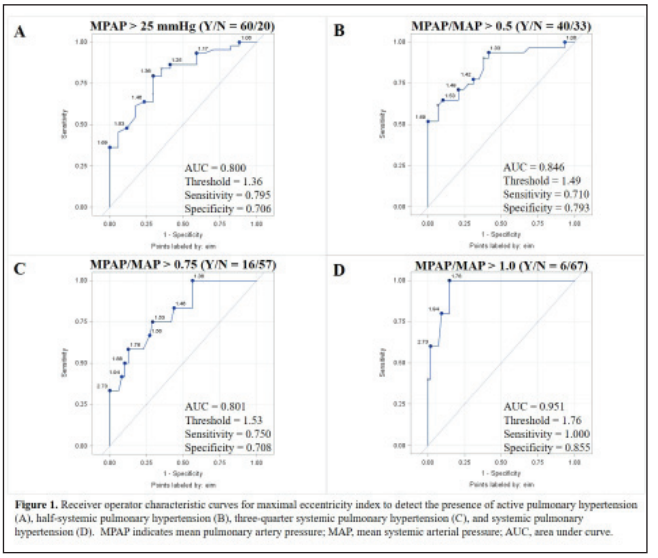

Figure 1. Receiver operator characteristic curves for maximal eccentricity index to detect the presence of active pulmonary hypertension (A), half-systemic pulmonary hypertension (B), three-quarter systemic pulmonary hypertension (C), and systemic pulmonary hypertension (D). MPAP indicates mean pulmonary artery pressure; MAP, mean systemic arterial pressure; AUC, area under curve.

Poster Session 1 (P1) **Sunday, June 24, 2018**

POSTER SESSION 1 (P1)

Presented Sunday, June 24, 9:00 AM-4:00 PM

Cardio-Oncology
P1-01 through P1-12

Adult Congenital Heart Disease
P1-13 through P1-17

Pediatric Heart Disease
P1-18 through P1-81

Clinical Cases: Pediatric Patients
P1-82 through P1-91

Diseases of the Aorta / Vascular Disease
P1-92 through P1-104

Valvular Heart Disease
P1-105 through P1-148

3D Echocardiography
P1-149 through P1-176

Doppler / Hemodynamics
P1-177 through P1-193

Echocardiography in Systemic Disease (DM, HTN, Obesity) / Pericardial Disease / Primary Myocardial Disease
P1-194 through P1-223

P1-01

Cardiac Response to Chimeric Fibril-Reactive Monoclonal Antibody 11-1F4 in Patients with AL Amyloidosis with Global Longitudinal Strain: Results from the Phase 1b trial

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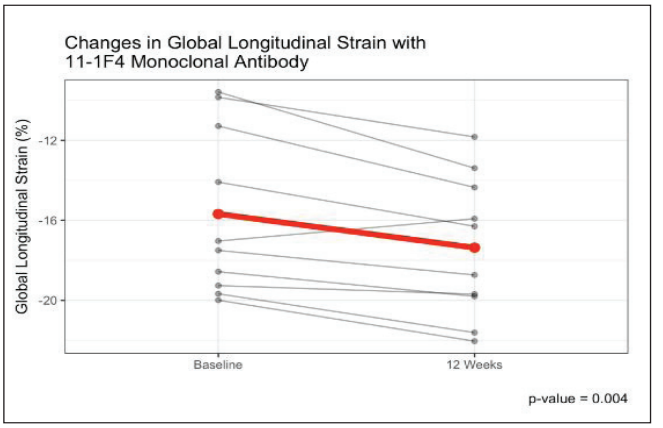
Background: Cardiac involvement with AL amyloid portends poor prognosis. The amyloid fibril-reactive monoclonal antibody (mAb) 11-1F4 was developed to target amyloid deposits by binding to a conformational neoepitope on human light-chain amyloid fibrils leading to amyloidolysis. An open-label phase 1b clinical trial of the mAb has been completed with promising results. We aim to assess the response of myocardial function to mAb administration using global longitudinal strain (GLS). **Methods:** Nineteen patients with relapse or refractory AL Amyloidosis were enrolled into the trial (age ± SD, 63 ± 12; 68% male). Fifty three percent had light chain kappa amyloid and 52% had cardiac involvement as defined by NTpro-BNP level of > 650 pg/ml. The mAb was administered weekly for 4 weeks with sequential doses of 0.5, 5, 10, 50, 100, 250 and 500 mg/m^2 in a dose-escalation design. Clinical echocardiographic examinations at baseline and 12 weeks post therapy were compared. Several echocardiographic variables including left ventricular ejection fraction (LVEF) (calculated using Simpson's biplane method) were obtained. GLS was measured using speckle-tracking (TomTec-Arena 1.2, Germany) and calculated as an average of 4-, 2-,and 3- chamber based measurements. Paired student's t-test was used to compare echocardiographic variables at baseline and 12 weeks after therapy with mAb. **Results:** While there was neither significant change between LVEF (56.2 ± 8.6% vs. 56.2 ± 9.5%, p = 0.985) nor GLS (-19.04 ± -5.11% vs. -19.73 ± -4.1%, p = 0.119) from baseline to 12 week examinations for the overall cohort, patients with cardiac involvement demonstrated an improvement in GLS (-15.58 ± -4.14% pre and -17.37 ± -3.53% post, p = 0.004 (Figure 1). Subgroup analysis showed an improvement in GLS in patients with lambda amyloid cardiac involvement (- 14.3 ± - 4.38% pre and -16.17 ± -3.74% post, p = 0.02) and a trend in improvement with kappa amyloid cardiac involvement (-16.60 ± - 4.10% pre and -18.16 ± -3.48% post, p = 0.07). **Conclusion:** This is the first trial to show a significant improvement in GLS after exposure to an anti-fibril specific mAb in subjects with AL amyloid cardiac involvement. This preliminary data will aid in designing a larger clinical trial. Additionally, larger trials leveraging GLS to evaluate myocardial function are warranted.



P1-02

Long-Term Cardioprotective Effects of Dexrazoxane Infusion During Anthracycline Chemotherapy: A Children's Oncology Group Speckle Echocardiography Study

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Background: Dexrazoxane (DRZ) has been shown to be cardioprotective in patients receiving anthracycline chemotherapy, although its effects on myocardial mechanics are unclear. We hypothesized that left ventricular function, as assessed by global longitudinal strain (GLS) on speckle tracking echocardiography, will be preserved in patients who received DRZ with anthracyclines, versus those who did not. **Methods:** Pediatric leukemia and lymphoma patients who were randomly assigned to doxorubicin (cumulative doses 100-360 mg/m^2) ± DRZ therapy (10:1 mg dose ratio DRZ:doxorubicin) on frontline national pediatric clinical trials from 1996-2001, underwent long-term follow-up with echocardiograms (2014-2017). For the current study, echocardiograms saved in the DICOM format were analyzed offline using vendor-independent software (TomTec) by a single reader blinded to clinical data. Global end-systolic (defined as the time of aortic valve closure) endocardial, myocardial, and peak longitudinal strain (average of 6 segments) were obtained from the apical 4-chamber view. Peak systolic global radial and circumferential strain were obtained from the parasternal short-axis view at the papillary muscle level. To compare outcomes by DRZ status, we used t-test, chi-square, and multivariable linear regression adjusted for age, sex, and treatment protocol. **Results:** We evaluated 105 patients (mean follow-up age 27.7 y; 16.5 y since cancer diagnosis; 54% received DRZ). There were no significant differences in demographic or treatment characteristics by DRZ status (Table). Compared with the DRZ+ group, the DRZ- group had significantly lower endocardial, myocardial, and peak GLS (Table). In subanalyses, these differences were seen among patients treated with doxorubicin ≥250 mg/m^2 but not <250 mg/m^2. In multivariable regression, DRZ status remained significantly associated with GLS endocardial (coefficient -1.55; SE 0.69; p=0.028). No differences in radial or circumferential strain were observed. **Conclusions:** In long-term follow-up of childhood cancer survivors, use of DRZ with anthracycline chemotherapy was associated with preserved myocardial mechanics, specifically GLS, at an average of 16.5 years after cancer treatment. Further studies are warranted to assess change in strain parameters over time.

Poster Session 1 (P1)

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*After adjustment for sex, age, and cancer treatment protocol; †Available for 59 (DRZ+, n=33)			
Characteristics	DRZ+ N=57	DRZ- N=48	P-value
Female sex, %	38.6	52.1	0.17
Mean age at echocardiogram ± SD, years	27.3 ± 5.0	28.1 ± 5.3	0.44
Mean age at diagnosis ± SD, years	10.8 ± 5.1	11.5 ± 5.3	0.45
White non-Hispanic race/ethnicity, %	87.2	86.1	0.87
Original cancer diagnosis, %			0.53
Acute lymphoblastic leukemia (ALL)/ lymphoma	56.1	50.0	
Hodgkin lymphoma	43.9	50.0	
Cancer treatment protocol, %			0.25
Pediatric Oncology Group 9404	45.6	45.8	
Pediatric Oncology Group 9425	14.0	27.1	
Pediatric Oncology Group 9426	29.8	22.9	
Dana Farber Cancer Institute ALL Consortium 95-01	10.5	4.2	
Mean doxorubicin dose ± SD, mg/m^2	282 ± 90	275 ± 98	0.71
Exposed to heart radiation, %	31.6	47.9	0.087
Mean heart XRT dose, cGy	2375 ± 226	2300 ± 218	0.29
Global longitudinal strain ± SD, %			
Endocardial	-20.4 ± 2.9	-19.0 ± 3.8	0.027 / 0.028*
Myocardial	-16.0 ± 2.4	-14.5 ± 3.2	0.010 / 0.010*
Average endocardial peak	-20.1 ± 3.0	-18.6 ± 3.8	0.030 / 0.031*
Average myocardial peak	-15.7 ± 2.6	-14.2 ± 3.3	0.012 / 0.012*
Global circumferential strain (endocardial) ± SD, %	-21.7 ± 4.5	-21.4 ± 4.5	0.75 / 0.57*
Global radial strain (short axis) ± SD, %	30.6 ± 15.6	27.5 ± 17.2	0.33 / 0.24*
Fractional shortening ± SD, %	34.5 ± 4.2	33.3 ± 4.8	0.17 / 0.26*
Biplane ejection fraction ± SD, %†	62.4 ± 6.2	58.2 ± 6.7	0.015 / 0.032*
Posterior wall thickness:LV dimension ratio ± SD	0.176 ± 0.041	0.185 ± 0.047	0.35 / 0.39*

P1-03

Early Declines in Global Longitudinal Strain and Subsequent Decline in Ejection Fraction Following Anthracycline Chemotherapy for Pediatric Cancer

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Background: Early detection of anthracycline (AC) cardiotoxicity may enable timely intervention to mitigate late cardiomyopathy. Speckle tracking based global longitudinal strain (GLS) may be useful to detect early cardiotoxicity. **Methods:** Trans-thoracic echocardiography was performed in 93 pediatric cancer patients at baseline and end of AC therapy; 58 of these also had an echo 1 year after therapy. Digitally archived echo data was analyzed for systolic function [fractional shortening (FS), ejection fraction (EF)], left ventricular (LV) posterior wall diameter, LV internal diastolic dimension, and LV mass index. GLS was analyzed in 78 patients using Tomtec® software using apical 4, 3 and 2 chambers. Generalized estimating equations were used to evaluate the change in each echo parameter at end AC and 1 year later and the relationship between AC dose and GLS decline. Finally, the relationship between decline in GLS at the end of therapy and decline in EF 1 year later was evaluated using linear regression. **Results:** Patients with a median age of 9.9 years (range 1 month to 21 years) received a median AC dose of 200mg/m^2 (range 75-492mg/m^2 doxorubicin equivalents); 20% received dexrazoxane. Seventeen patients (18%) had abnormal GLS (> -15%) at baseline, most of whom (12 of 17) had fever, anemia, hyperleukocytosis and/or a mediastinal mass at diagnosis. Measures of systolic function, LV wall thickness and LV mass decreased throughout the study period (Table 1). There was a trend toward greater decline in GLS with increasing AC dose (1.04% GLS decline for every 100 mg/m^2 dose increment, p=0.08). Decline in GLS at the end of therapy was associated with a decline in EF at 1 year (slope -0.37, p=0.04). Eleven patients (12%) developed LV systolic dysfunction (FS≤28% or EF≤50%) during the study period, 7 of whom had abnormal GLS at a preceding time point. **Conclusions:** GLS is load-sensitive and may be abnormal at baseline in pediatric cancer patients, possibly related to illness at the time of presentation. GLS further declines at the end of AC therapy and is associated with a decline in EF 1 year later. Thus, monitoring GLS during AC therapy may aid in early prediction of cardiomyopathy.

	Time Point	Median (IQR)	Change from Baseline[$]	Standard Error[$]	P-value[$]
GLS	Baseline	-17.8% (-21%,-14.6%)			
	End of Therapy	-16% (-18%,-12.4%)	**2.1%**	**0.006**	**<0.001**
	1 Year After Therapy	-17.4% (-19%,-15%)	0.4%	0.006	0.55
EF	Baseline	65% (61%,68%)			
	End of Therapy	62% (59%,65%)	**-2.6%**	**0.007**	**<0.001**
	1 Year After Therapy	63% (60%,65%)	**-2.1%**	**0.007**	**0.005**
SF	Baseline	38% (34%,41%)			
	End of Therapy	36% (33%,38%)	**-2.1%**	**0.006**	**<0.001**
	1 Year After Therapy	36% (35%,39%)	**-1.9%**	**0.006**	**0.004**
LVPWd (Z-score)	Baseline	-0.88 (-1.54,-0.31)			
	End of Therapy	-1.29 (-1.79,-0.66)	**-0.37**	**0.14**	**<0.01**
	1 Year After Therapy	-1.23 (-1.83,-0.42)	-0.21	0.18	0.23
LVIDd (Z-score)	Baseline	0.11 (-0.72,1.02)			
	End of Therapy	0.00 (-0.68,0.78)	-0.05	0.12	0.66
	1 Year After Therapy	-0.095 (-0.865,0.648)	-0.16	0.11	0.15
LV Mass Index (g/m2)	Baseline	34.9 (28.7,45.8)			
	End of Therapy	30.7 (26.2,41.7)	**-3.481**	**1.360**	**0.01**
	1 Year After Therapy	32.7 (26.0,38.1)	**-3.944**	**1.417**	**0.005**

Table 1. Trends in LV Structure and Function After Anthracyclines. [$]Change from baseline & associated statistics adjusted for age, sex and dexrazoxane use

P1-04

Left Atrial Dysfunction in Children Following Anthracycline Treatment: A Real Time Three-Dimensional Echocardiography Study

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Background: Anthracycline (AC) therapy is associated with left ventricular (LV) dysfunction. Left atrial (LA) size and function are used to assess LV diastolic function in heart failure. Data on LA size and function following AC therapy is limited. We hypothesized that LA size and function will be abnormal in children following AC chemotherapy. **Methods:** This retrospective review included patients who received AC for pediatric cancers over 1 year prior to enrollment. Patients with LV dysfunction (shortening fraction <28%) or following bone marrow transplant were excluded. Controls had normal echocardiograms performed for evaluation of chest pain, murmur or syncope. Real time three dimensional echocardiography (RT3DE) was performed (Philips I33) and data was analyzed using QLAB 10.3 offline by a single reader blinded to clinical data. Maximum LA (LA max) volume at end systole, minimal LA volume (LA min) at end diastole and volume before atrial contraction (LA pre a) were obtained. LA reservoir function was assessed by filling volume (LA max - LA min), expansion index ([LA max - LA min]/LA min) x100) and diastolic emptying index ([LA max - LA min]/LA max x 100). Conduit function was evaluated by calculating passive emptying % of total emptying ([LA max - LA pre a]/[LA max - LA min] x 100) and passive emptying index ([LA max - LA pre a]/LA max) x 100). Booster pump function was assessed by calculating active emptying % of total emptying (([LA pre a - LA min]/ [LA max - LA min]) x 100) and active emptying index ((([LA pre a - LA min]/ LA pre a) x 100). Groups were compared by student t-test and chi square test. **Results:** We evaluated 113 patients, 28(24.8%) of who received AC. The two groups were comparable in age, body surface area and gender distribution. LAmax was significantly smaller and active emptying index and LA ejection fraction were significantly lower in AC group compared to controls. The AC group also had lower filling volumes and diastolic emptying index in comparison to controls. **Conclusions:** It is intriguing that AC treated children have smaller LA reservoir and abnormal booster LA function, compared to controls. We speculate that these findings may reflect changes in LA compliance associated with AC exposure. Assessment of LA volumes and function on RT3DE as prognostic markers of AC induced cardiotoxicity in children is warranted.

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Sunday, June 24, 2018

Table: Comparison of demographic and various LA size and function parameters			
Parameters - Mean ± SD or n (%)	AC group (n=28)	Control group (n=85)	P
Age (years)	13.2±3.4	12.1± 4	0.21
Gender (male)	18 (64.3)	51(60)	0.3
Weight (kg)	54.2 ± 23	48.5 ± 20.5	0.22
Body surface area (m2)	1.5 ± 0.4	1.4 ± 0.4	0.175
LA max (ml/m2)	14.8 ± 4.5	17.2 ± 5.7	**0.044**
LA min (ml/m2)	5.1 ± 2	5.3 ± 2.2	0.676
LA pre A (ml/m2)	10.8 ± 3.7	12.1 ± 4.5	0.168
Filling volume (ml/m2)	9.6 ± 3.3	11.9 ± 3.8	**0.007**
Expansion index (%)	202.9 ± 73.8	237 ± 59.9	**0.016**
Diastolic emptying index (%)	65.1 ± 8.3	69.5 ± 5.1	**0.001**
Passive emptying percent of total emptying (%)	41.4 ± 11.1	42.3 ± 10.2	0.710
Passive emptying index (%)	27.1 ± 8.4	29.5 ± 7.7	0.169
Active emptying percent of total emptying (%)	58.6 ± 11.1	57.7 ± 10.2	0.710
Active emptying index (%)	52.2 ± 9.6	56.5 ± 6.7	**0.010**
LA Ejection fraction (%)	65.2 ±8.3	69 ± 6	**0.011**

P1-05

Relationship Between Tacrolimus-Induced Cardiomyopathy and Blood Concentration of Tacrolimus after Bone Marrow Transplantation

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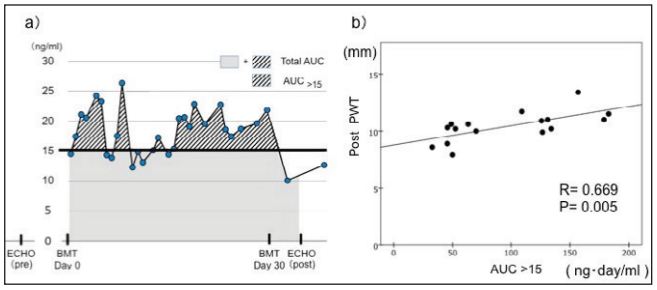
Backgrounds: Tacrolimus (TAC) has been used for prophylaxis and treatment of graft rejection after solid organ transplantation, and acute graft-versus-host-disease after bone marrow transplantation (BMT). There are a few reports that patients after BMT developed left ventricular (LV) hypertrophy during TAC treatment, i.e., tacrolimus-induced cardiomyopathy (TICM). However, it remains unclear whether high blood concentration of TAC relates TICM. In this study, we investigated whether blood concentration of TAC have a relationship with cardiac dysfunction in patients after BMT. **Methods:** We enrolled 16 consecutive patients (10 men, 44.6±13.0 years), who received BMT and were treated by TAC. Echocardiography was performed before and about one month after BMT in the stable state. The parameters of TAC blood level were evaluated as AUC_{Total} (sum of TAC concentration), C_{mean} (mean concentration), and $AUC_{>15}$ (the area sum of TAC concentration greater than 15 ng/ml) during the follow-up period (Fig-a). We investigated whether the change of wall thickness, systolic and diastolic function related to the parameters of TAC. **Results:** During the follow-up period (47.6±13.7 days), 2 of 16 patients (12.5%) developed heart failure. After BMT, the LV septum thickness (IVST) (pre to post: 8.7±1.2 to 9.9±1.7 mm, P=0.001) and the posterior wall thickness (PWT) (9.0±1.1 to 10.4±1.3 mm, P<0.001) significantly increased, and the LV diastolic dimension was significantly reduced (46.4±4.0 to 41.5±7.5 mm, P=0.006). Although there was no difference in the LV ejection fraction, E´ significantly decreased (8.8±2.2 to 6.8±1.6 cm/sec, p=0.006). $AUC_{>15}$ had significant relationships with post-IVST (R=0.627, P=0.009), post-PWT (R=0.669, P=0.005), and post-E´ (R=-0.767, P=0.001) (Fig-b). By multivariate analysis, $AUC_{>15}$ and age were independent predictors for increasing of PWT after treatment by TAC in patients with BMT. **Conclusions:** Blood concentration of TAC ($AUC_{>15}$) had a relationship with diastolic dysfunction in patients after BMT. Since the occurrence of diastolic heart failure by TICM relates with prognosis in patients after BMT, it is very important to monitor the parameter of $AUC_{>15}$ and echocardiography for preventing TICM.



P1-06

Global Longitudinal Strain is a Strong, Independent Marker of Prognosis Among Patients with Advanced AL Amyloidosis

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Background: Prognostically validated revised Mayo staging system based on cardiac biomarkers and difference in free light chains (FLC-d) is commonly used for risk stratification and prediction of overall survival (OS) in newly diagnosed patients with AL amyloidosis. An advanced revised Mayo stage (III or IV) is associated with poor OS. The additive role of left ventricular structure and function indices to predict OS in this patient population is uncertain. **Methods:** A retrospective analysis of 81 patients with newly diagnosed biopsy-proven AL amyloidosis with revised Mayo stage III or IV was performed. Clinical, serologic, and 2D echo data were collected prior to treatment. Global longitudinal strain (GLS) was measured offline using AutoStrain software (Tom Tec Imaging Systems). The primary endpoint was all-cause mortality. **Results:** Sixty (74%) deaths were observed at a mean follow-up of 2.3 ± 2.7 years. All patients underwent chemotherapy, with 9 (11%) patients receiving stem cell transplant as initial treatment. In univariate analysis, brain natriuretic peptide (BNP), ejection fraction (EF), E/e' ratio, deceleration time, cardiac index, and GLS were associated with survival. FLC- d, troponin, and hematologic status at 1 year were not. In a multivariate model that included BNP, E/e' ratio, EF, and FLC-d, GLS remained as the only significant predictor, with a cut-off of 15% best discriminating survivors versus non-survivors.

Table 1. Baseline Demographic, Clinical, and Echocardiogram Characteristics, N = 81

Variable	All Patients	Survivors (N = 21)	Non-survivors (N = 60)
Male	51 (63)	16 (76)	35 (58)
Age	64 (38 – 85)	59 (44 – 77)	64 (38 – 85)
BMI, kg/m^2	27.0 ± 4.5	27.0 ± 3.4	27.0 ± 4.8
SBP, mmHg	116 ± 17	115 ± 17	116 ± 17
DBP, mmHg	71 ± 11	72 ± 11	71 ± 11
HR, beats/min	80 ± 14	81 ± 15	80 ± 14
Hypertension	39 (48)	11 (52)	28 (47)
Hyperlipidemia	30 (37)	8 (38)	22 (37)
Chronic kidney disease	35 (43)	7 (33)	28 (47)
Atrial fibrillation	13 (16)	1 (5)	12 (20)
Coronary artery disease	10 (12)	3 (14)	7 (12)
Troponin I, µg/mL	0.20 ± 0.22	0.14 ± 0.08	0.22 ± 0.25
≥ 0.1 µg/mL	59 (73)	16 (76)	43 (72)
BNP, pg/mL	980 ± 859	874 ± 840	1018 ± 746
≥ 400 pg/mL	65 (80)	15 (71)	50 (83)
FLC difference, mg/L	73.5 ± 108.0	100.1 ± 153	64.0 ± 86.6
≥ 18 mg/L	67 (83)	18 (86)	49 (82)
Serum creatinine, mg/dL	1.8 ± 1.4	1.7 ± 1.6	1.7 ± 1.3
Revised Mayo stage			
III	51 (63)	14 (67)	37 (62)
IV	30 (37)	7 (33)	23 (38)
1-year hematological state, N = 38			
Non-CR	31 (82)	15 (79)	16 (84)
CR	7 (18)	4 (21)	3 (16)
Follow-up after echocardiogram, years	2.3 ± 2.7	5.0 ± 3.9	1.4 ± 1.6
GLS, %	14.3 ± 5.3	15.5 ± 5.0	13.9 ± 5.3
LVEF, %	59 ± 11	61 ± 11	58 ± 11
IVS thickness, cm	1.4 ± 0.3	1.4 ± 0.3	1.4 ± 0.3
E/e' ratio	18.0 ± 6.7	16.5 ± 4.7	18.5 ± 7.3
Deceleration time, sec	0.18 ± 0.05	0.19 ± 0.06	0.17 ± 0.05
LA volume index, mL/m^2	37 ± 12	37 ± 13	37 ± 12
Cardiac index, L/min/m^2	2.4 ± 0.8	2.6 ± 0.7	2.3 ± 0.8

Values are expressed in N (%), median (range), or mean ± SD.
BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; BNP, brain natriuretic peptide; FLC, free light chain; NR, no response; PR, partial response; VGPR, very good partial response; CR, complete response; GLS, global longitudinal strain; LVEF, left ventricular ejection fraction; IVS, interventricular septum; E/e', ratio of peak early diastolic mitral inflow velocity (E) to peak early diastolic mitral annular velocity (e'); LA, left atrium.

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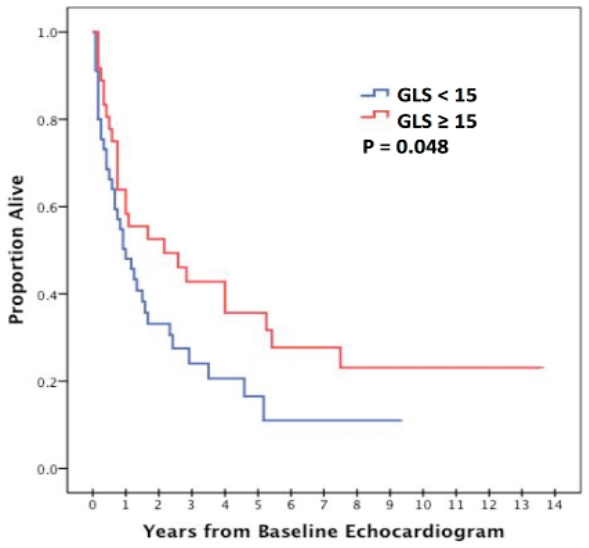
Table 2. Univariate Predictors of Overall Survival

Variable	Hazard Ratio (95% CI)	P value
Sex (male)	0.79 (0.47 – 1.32)	0.36
Age	0.37 (0.99 – 1.04)	0.37
SBP	0.99 (0.98 – 1.01)	0.44
DBP	0.99 (0.97 – 1.01)	0.42
HR	1.01 (0.99 – 1.03)	0.27
BNP*	1.41 (1.04 – 1.92)	0.03
Troponin I*	1.21 (0.87 – 1.69)	0.28
FLC difference*	0.91 (0.74 – 1.11)	0.35
Revised Mayo stage	1.61 (0.95 – 2.73)	0.08
Serum creatinine	0.99 (0.83 – 1.19)	0.93
1-year hematologic state, N = 38 Non-CR VS CR	0.73 (0.21 – 2.52)	0.62
GLS	0.93 (0.88 – 0.96)	0.003
LVEF	0.97 (0.95 – 0.99)	0.009
IVS thickness	1.47 (0.67 – 3.21)	0.34
E/e' ratio	1.04 (1.00 – 1.08)	0.05
Deceleration time	0.001 (0.00 – 0.59)	0.03
LA volume index	0.99 (0.97 – 1.02)	0.55
Cardiac index	0.67 (0.44 – 1.00)	0.05

* Hazard ratios calculated using log-transformed values.
Abbreviations as in Table 1.

Figure 1. Kaplan-Meier Curve for Overall Survival According to GLS Cut-off Value of 15%



Conclusions: In patients with advanced AL amyloidosis, pre-treatment GLS is a strong, independent predictor of survival. GLS should be considered as part of risk stratification and clinical decision-making in this especially high-risk cohort. Larger studies are required to validate the optimal GLS cutoff.

P1-07

Subcostal Strain in Breast Cancer Patients: Exploring an Alternative to Traditional Apical Longitudinal Strain

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Background: Strain imaging is often technically limited in patients with breast cancer (CA) due to tissue expanders, implants and/or surgery. Our 2017 pilot study showed that subcostal strain was a novel and feasible technique in 19 patients. In the current study, we examined a larger cohort of female patients with breast cancer and performed a segmental analysis. **Methods:** Longitudinal strain (LS) was measured in the apical and subcostal 3-chamber (3C) and 4-chamber (4C) views among breast CA patients. Two-dimensional speckle tracking was performed using GE EchoPAC software. Correlation between measurements was calculated using intraclass correlation coefficients. Bland-Altman analysis was used to evaluate the agreement between apical and subcostal LS measurements. **Results:** 102 studies from 65 patients were analyzed. 8 studies were excluded due to inadequate subcostal (n=6) or apical (n=2) views. Mean apical and subcostal LS was -21.2% and -20.7%, respectively for 3C and -21.6% and -22.2%, respectively for 4C. Apical and subcostal LS measurements were correlated for both 3C ($r^2 = 0.27$, $p < 0.001$) and 4C ($r^2 = 0.14$, $p < 0.001$) views. Correlations remained significant, but were not appreciably different, when apical segments were excluded. There was good agreement between measurements in apical and subcostal 3C and 4C views. Segment by segment analysis also showed significant correlation between apical and subcostal LS measurements for all but 2 segments (Table 1). **Conclusion:** In a large cohort of patients, we demonstrated that subcostal 3C and 4C LS can be reliably measured, with good agreement with traditional apical LS. Importantly, the subcostal view may provide a novel alternative for trending LS in patients with breast cancer who have technically limited apical windows. Further prospective research is needed.

Table 1: Segment by Segment Analysis

	Mean Apical LS	Mean Subcostal LS	p-value
Basal Inferolateral	-20.1	-19.1	**0.12**
Mid Inferolateral	-20.0	-20.1	0.02
Apical Inferolateral	-23.0	-23.0	0.03
Basal Anteroseptal	-23.2	-20.8	<0.001
Mid Anteroseptal	-21.8	-20.2	<0.001
Apical Anteroseptal	-20.7	-20.6	<0.001
Basal Inferoseptal	-17.9	-18.6	**0.06**
Mid Inferoseptal	-20.9	-21.1	0.02
Apical Inferoseptal	-27.1	-26.1	<0.001
Basal Anterolateral	-22.7	-23.1	<0.001
Mid Anterolateral	-20.3	-22.1	0.04
Apical Anterolateral	-21.1	-22.3	<0.001

P1-08

Assessment of Early Radiation Induced Changes in Left Ventricular Contractile Function by Myocardial Strain Imaging after Breast Radiation Therapy

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Background: Radiotherapy (RT) induced cardiotoxicity is a worrisome adverse effect of breast cancer (BCA) treatment, and has led to the development of newer techniques that reduce radiation dose to the heart. We evaluated whether RT results in subclinical changes of left ventricular (LV) function among HER2-positive BCA patients at increased risk for cardiotoxicity from anthracycline and trastuzumab treatment, and whether these changes are associated with mean heart dose (MHD). **Methods:** We prospectively studied 48 women with HER2-positive BCA treated with doxorubicin, trastuzumab, and RT to the breast/chest wall +/- regional lymph nodes from 2014-2016. 2D echocardiography with speckle tracking imaging was performed at baseline (pre-chemotherapy), before and after RT, and upon completion of trastuzumab (end of treatment). Associations between MHD and changes in LV ejection fraction (LVEF), diastolic indices, and myocardial deformation indices after RT were examined. **Results:** The mean age was 52 years. The MHD was higher (2.3 ± 2.3 Gy vs 1.1 ± 1.7 Gy, p=0.002) for patients receiving left- (N=27) versus right-sided (N=21) RT. Pre-RT, post-RT, and end of treatment echocardiograms were performed a median of 48 days before and 56 and 196 days after RT, respectively. Compared to pre-RT, a modest decrease in LVEF (61 ± 7% vs. 59% ± 8%, p = 0.002) but not in longitudinal, circumferential, or radial strain or diastolic indices was observed post-RT. In a group of 12 patients that received a MHD > 2 Gy, there was no significant difference in LVEF or myocardial strain pre- versus post-RT. At end of treatment, there was no significant change in systolic or diastolic indices of LV function compared to pre-RT. In a multiple regression model, MHD was not associated with changes in LVEF or global longitudinal strain after RT, adjusting for age, hypertension, and baseline LVEF.

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Table 1. Summary of echocardiographic parameters during breast radiotherapy (N=48)

	Baseline	Pre-RT	Post-RT	Final F/U
LA volume index (mL/m²)	24 ± 8	25 ± 7	26 ± 7	24 ± 7
LV mass index (g/m²)	71 ± 15	77 ± 13	77 ± 14	75 ± 15
LVEDd/BSA (mm/m²)	2.6 ± 0.2	2.7 ± 0.3	2.7 ± 0.3	2.7 ± 0.3
LVEF (%)				
Median	65	61.5	61	61
Range	53 – 75	35 – 76	33 – 66	35 – 74
Mean ± SD	65.3 ± 4.1	60.9 ± 7.2	58.6 ± 7.6*	60.4 ± 6.9
Longitudinal Strain (%)				
A3C	-20.5 ± 2.5	-18.7 ± 2.7	-18.3 ± 3.2	-18.5 ± 2.9
A4C	-20.6 ± 2.1	-18.6 ± 2.7	-18.5 ± 2.8	-18.3 ± 2.2
A2C	-21.6 ± 3.0	-19.3 ± 3.5	-19.1 ± 3.3	-19.2 ± 2.4
Global	-20.8 ± 2.1	-18.9 ± 2.8	-18.7 ± 2.9	-18.7 ± 2.3
Circumferential strain (%)	-19.0 ± 4.0	-16.6 ± 3.7	-17.5 ± 3.3	-16.3 ± 4.3
Radial Strain (%)	42.4 ± 16.3	40.1 ± 17.4	41.6 ± 24.5	36.7 ± 14.9
Diastolic Parameters				
Mitral E velocity (cm/sec)	79.8 ± 18.2	82.5 ± 15.0	78.8 ± 12.8	77.5 ± 16.5
Mitral A velocity (cm/sec)	75.3 ± 16.0	75.1 ± 19.8	71.0 ± 16.5	72.8 ± 17.4
Mitral E/A ratio	1.1 ± 0.4	1.2 ± 0.4	1.2 ± 0.4	1.1 ± 0.4
Septal e' (cm/sec)	9.1 ± 2.5	9.1 ± 2.4	8.8 ± 2.3	8.7 ± 2.5
Lateral e' (cm/sec)	12.2 ± 3.5	11.3 ± 3.9	11.1 ± 3.5	11.2 ± 3.4
Septal E/e' ratio	9.4 ± 2.4	9.5 ± 2.3	9.3 ± 8.8	9.4 ± 3.0
Lateral E/e' ratio	7.0 ± 1.9	8.1 ± 2.8	7.6 ± 2.2	7.4 ± 2.4

Data given as mean ± SD unless otherwise specified.
LA, left atrial; LV, left ventricular, LVEDd, left ventricular end diastolic diameter; BSA, body surface area, LVEF, left ventricular ejection fraction, A3C, apical 3 chamber; A4C, apical 4 chamber; A2C, apical 2 chamber
*P < 0.05 for comparison with pre-RT timepoint

Conclusion: In this single center study, no change in myocardial deformation indices was observed after RT. These results suggest that RT can safely be delivered using current conventional techniques without significant evidence of early subclinical LV dysfunction in patients treated with anthracyclines and trastuzumab. Myocardial strain imaging may not be a useful tool in the evaluation of early RT induced cardiotoxicity, particularly when a low MHD is delivered.

P1-09

Outcomes of Cancer Patients Undergoing Echo-guided Pericardiocentesis: Experience Over 10 Years

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Background: Pericardial effusions are common in cancer patients. The findings, immediate safety and longer-term outcomes of pericardiocentesis are less well defined. **Methods:** We reviewed the cases of all patients with malignancy that underwent echo-guided pericardiocentesis at our institution between 2007 and 2016. **Results:** Over a 10-year period, 172 patients with cancer underwent echo-guided pericardiocentesis. 53% were male with a mean age of 60 +/- 15 years of age. The average volume removed was 485 (350-719) ml. The site of drainage was left anterior/para-apical in most (71%), 13% from left parasternal, 5% from right parasternal and 11% from subcostal access. Twenty percent had hemorrhagic, 48% had serosanguinous and 31% serous pericardial effusions. The type of effusion was not associated with outcome. The procedure was technically successful in 171/172 (99.4%) of patients without significant complication or procedure-related death. Cytology (measured in 164) was positive in 58% and only weekly related to outcome (median survival 9 versus 18 weeks, p=0.04). A pericardial catheter was left in place until there was less than 50 ml of net drainage in 24 hours (average 2.9 +/- 1.7 days). The time of pericardial catheter use was not associated with outcome. 135 patients had metastatic carcinoma, 23 had lymphoma or chronic leukemia and 4 metastatic sarcoma. Patients with either lymphoma or chronic leukemia had better survival than those with carcinoma or sarcoma (median survival 102 versus 12 weeks, p<0.0001) with a 46% versus 3% 5-year survival, p<0.0001). **Conclusions:** Echo-guided pericardiocentesis is safe and effective in patients with malignant pericardial effusions. However overall outcomes are poor in cancer patients with pericardial effusions, particularly those with carcinoma or sarcoma.

P1-10

Rates of Cardiac Dysfunction in Patients Undergoing Surveillance Echocardiography for Cardiotoxic Chemotherapy and Associated Clinical Outcomes

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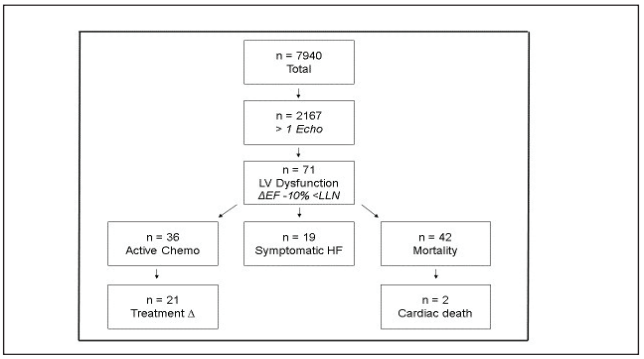
Background: We investigated echocardiographic findings and clinical outcomes in patients referred for echocardiography during/following chemotherapy. **Methods:** We reviewed our echocardiography database to identify all studies specifically performed in cancer patients receiving cardio-toxic agents referred for baseline and serial evaluation between January 2011 and June 2017. Cardiac dysfunction was defined as reduction in left ventricular ejection fraction (LVEF) > 10% from baseline to less than the lower limit of normal. Clinical outcomes were obtained by assessment of the electronic patient medical record. **Results:** A total of 13198 echocardiograms from 7940 patients were identified, of which 13094 studies had an LVEF reported. 2167 patients had serial (>1) tests performed (7321 echocardiograms, median 4 studies per patient). Cardiac dysfunction was reported in 161 echocardiograms from 71 patients (3% of patients with >1 study). Cardiotoxic exposures in this sub-cohort included anthracyclines (49 patients, 69%), radiation (29 patients, 41%), and Her-2 blockers (18 patients, 25%). Of these 71 patients with cardiac dysfunction, 36 patients were actively undergoing chemotherapy, 21 (58%) of which had their regimen either held or changed. Subsequent echocardiograms were performed in 43 of these 71 patients, 29 (66%) of which had ongoing cardiac dysfunction while 14 (33%) had a normalized LVEF. Of these 71 patients with cardiac dysfunction, 19 (27%) developed symptomatic heart failure (HF) as diagnosed by the treating cardiologist. By the end of 2017, 42 (59%) of these 71 patients had died, of which 2 patients had documented death due to a cardiac cause. The mean time to death after initial LVEF reduction in these patients was 10 months (range of 1 week to 43 months). The mean time from cancer diagnosis to cardiac dysfunction was 15±17 months in those that died vs. 26±30 months in those that survived (p = 0.011). **Conclusion:** Cardiac dysfunction was identified in 3% of patients undergoing serial echo, was associated with high mortality (mainly non-cardiac death) and occurred significantly sooner after cancer diagnosis in those that died.



P1-11

The Role of Baseline Transthoracic Echocardiography in Predicting Early Adverse Cardiac Events Following Allogeneic Hematopoietic Cell Transplantation

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Background: Allogeneic hematopoietic cell transplantation (HCT) is an increasingly utilized treatment option for patients with a variety of hematologic conditions. These patients are at increased risk of adverse cardiovascular events, but the incidence and risk factors of these events are not well described. The majority of patients have a transthoracic echocardiogram (TTE) performed as part of the pre-transplant work-up but the predictive value of this test remains unclear. **Methods:** After IRB approval, medical records of 256 consecutive acute myeloid leukemia (AML) patients that underwent HCT at our institution between 2005 and 2015 were reviewed. Data on demographics, transplant characteristics, cardiac risk factors, baseline TTE information and post-HCT adverse events were collected. Cardiovascular adverse events of grade ≥ 2 per the CTCAEv.4 criteria were defined as early adverse cardiac events (EACE) if they occurred within 100 days after HCT. The primary outcome measure was a composite of new diagnosis of heart failure, myocardial infarction, new diagnosis of valvular disease, arrhythmias or pericarditis. **Results:** EACEs were identified in 41 (16%) of the 256 patients in this study, with no difference in the incidence between the myeloablative vs. non-myeloablative conditioning regimens. Heart failure was the most common EACE, occurring in 7% of the patients. This was more commonly new onset heart failure as opposed to worsening of existing heart failure (5% vs. 1%, p = 0.01). Fifteen patients (5%) developed cardiac arrhythmias, while acute coronary syndrome was uncommon (1 patient, 0.5%). Pre-transplant ejection fraction (EF) was 60.8±0.39 (mean ± SEM), compared to 57.5±1.09 in the 100 days post-transplant (p=0.03). The incidence of EACE was higher in patients with a baseline EF<50% compared to those with an EF>50% (37.5% vs. 14.8%, p=0.03), with a risk ratio of 0.39 (95% CI 0.19-0.80). There was no association between baseline RVSP>40 mmHg (p=0.43), baseline diastolic dysfunction (p=0.987), mitral regurgitation of any severity (p=0.31), or aortic regurgitation of any severity (p=0.19) with the primary composite outcome. A logistic regression model of baseline E/A ratio and baseline RSVP as continuous variables did not show a significant association with the composite outcome (p = 0.05 and p = 0.2, respectively). **Conclusion:** A baseline EF>50% was associated with a lower risk of adverse cardiovascular events in patients with AML following HCT, with other echocardiographic variables studied not showing a statistically significant association.

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P1-12

Epidemiology and Outcomes of Transesophageal Echocardiogram Confirmed Non-Bacterial Thrombotic Endocarditis in Patients with Malignancy with Embolic Cerebrovascular Accidents

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Background: Non-Bacterial Thrombotic Endocarditis (NBTE) is associated with cerebrovascular accidents (CVA) in patients with malignancy. We sought to study the epidemiology and outcomes of patients with cancer who have an CVA in the presence of NBTE as diagnosed by transesophageal echocardiogram (TEE). **Methods:** We retrospectively reviewed 63 consecutive TEE cases performed at Memorial Sloan Kettering Cancer Center for the indication of embolic stroke in patients with cancer. Baseline demographics, clinical and imaging characteristics of the entire cohort were recorded. NBTE was defined as valvular vegetations in the absence of infectious or rheumatologic causes. The NBTE and non-NBTE groups were compared for differences in treatments, recurrent stroke, and mortality. Categorical variables were analyzed with Chi-square and Fisher's exact test while continuous variables were analyzed by Student's t-test. **Results:** Fourteen of the 63 cancer patients with suspected embolic stroke were found to have NBTE (22%). Baseline demographics were similar between patients with and without NBTE except history of venous thromboembolism (Table 1) was more common in the NBTE-group. Stage IV non-small cell lung cancer was the most common malignancy in both groups. Ninety-three percent of patients (13/14) in the NBTE-group were treated with systemic anticoagulation; most commonly with low-molecular weight heparin compared with only 27% of patients (13/49) in the non-NBTE group. Despite anticoagulation, the rate of recurrent stroke in the NBTE group was 29%, compared with 12% in the non-NBTE group (p=0.20). The 3-month early mortality was higher in the NBTE group than in the non-NBTE-group (64% vs 39%, p = 0.09). When present, valvular vegetations were found most often on the aortic valve (9) followed by the mitral valve (5). In the non-NBTE-group the most common TEE findings were PFO/ASD (28%), simple/complex aortic plaque (10%), atrial septal aneurysm (2%) and Lambl's excrescence (2%). **Conclusion:** In this cohort of patients with systemic malignancy, TEE-confirmed NBTE was responsible for 1 in 5 cases of embolic strokes. Despite systemic anticoagulation, NBTE-group had a high rate of recurrent embolism and a trend toward higher short-term mortality compared to the non-NBTE-group.

Table1- Baseline Demographics, Transesophageal Echocardiogram Findings, and Outcomes of Non-bacterial Thrombotic Endocarditis (NBTE) group vs. Non-NBTE group

Variable	All Patients N=63	14 NBTE (22%)	49 Non-NBTE (78%)	P value
Age Mean ± SD	63 ± 13	65 ± 8	62 ± 14	0.45
Male	32 (51)	8 (57)	24 (49)	0.59
Cancer stage Early Advanced	 7 (89) 56 (11)	 2 (14) 12 (86)	 5 (10) 44 (90)	0.65
Hypertension	30 (48)	8 (57)	22 (45)	0.42
Hyperlipidemia	23 (37)	6 (43)	17 (35)	0.58
Diabetes mellitus	10 (16)	1 (7)	9 (18)	0.43
Coronary artery disease	3 (5)	1 (7)	2 (4)	0.54
Atrial fibrillation	3 (5)	1 (7)	2 (4)	0.54
History of CVA	13 (21)	2 (14)	11 (22)	0.71
Venous thromboembolism	14 (22)	6 (43)	8 (16)	0.04*
Smoker	31 (49)	10 (71)	21 (43)	0.08
Anticoagulation treatment	26 (41)	13 (93)	13 (27)	<0.001*
Recurrent CVA while on anticoagulation (N = 26)	6 (23)	3 (23)	3 (23)	1.00
Death at 3 months	28 (44)	9 (64)	19 (39)	0.09

* Significant at P < 0.05
Values are expressed as N (%) unless otherwise specified
Cerebral vascular accident (CVA); Patent foramen ovale (PFO); Atrial septal defect (ASD)

P1-13

Right Ventricular Regional Remodeling Under Chronic Volume Overload in Adults with Atrial Septal Defect Evaluated by Three-Dimensional Echocardiography

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Background: To evaluate right ventricular (RV) regional remodeling under chronic volume overload in adults with atrial septal defect (ASD) using real-time three-dimensional echocardiography (RT3DE). **Methods:** Thirty consecutive adult patients with ASD and catheterization-measured mean pulmonary arterial pressure <25mmHg were enrolled. Thirty matched normal adults were included as controls. RT3DE was performed to evaluate RV regional end-diastolic volume (EDV) and end-systolic volume (ESV) in the inflow, body and outflow compartments. Regional volume percentage was calculated as regional volume divided by RV global volume measured by RT3DE. RV basal and longitudinal diameter, cardiac output (CO) of the right heart and pulmonary-to-systemic flow (Qp/Qs) ratio were measured by conventional echocardiographic method. **Results:** RT3DE analysis was successfully performed in 97% of the acquired images. The average ASD diameter was 16 ± 6 mm with left-to-right shunt. RV global and regional EDV and ESV in the patients were significantly higher than those in the controls ($P < 0.001$). Regional volume percentage of EDV and ESV in the body compartment in the patients was significantly increased ($P < 0.05$) when compared with the controls. Regional volume percentage of EDV in the inflow compartment and regional volume percentage of ESV in the outflow compartment were decreased in the patients ($P < 0.05$). Regional EDV in the body compartment was correlated with ASD diameter, CO and Qp/Qs ratio (r = 0.361 ~ 0.601, $P < 0.05$). Regional volume percentage of EDV in the body compartment was correlated with RV global EDV and RV basal diameter (r = 0.553 and 0.429, $P < 0.05$). **Conclusion:** Chronic volume overload leads to regional remodeling of the RV chamber, featuring a remarkable bulge of the body compartment. RT3DE may have added value in the evaluation of RV load conditions in adults with ASD.

P1-14

Misclassification of Bicuspid Aortic Valves is Common and Varies by Imaging Modality and Patient Characteristics

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Background: Bicuspid aortic valve (BAV) is the most prevalent adult congenital heart defect. BAV causes lifelong progressive disease that is responsible for more than half of aortic valve replacement surgeries in adults. Early diagnosis and long-term surveillance of BAV patients are essential to prevent complications, but may be compromised by misclassification of valve morphology. **Methods:** The UTHealth Bicuspid Aortic Valve Registry includes questionnaires, medical records and serial images from 250 participants with a mean follow-up of 2.8 years. In all cases, the diagnosis of BAV was confirmed by an expert clinician after visual inspection. Descriptions of aortic valve morphology were abstracted from transthoracic echocardiography (TTE), transesophageal echocardiography (TEE, excluding perioperative studies), computed tomography angiography (CT) and magnetic resonance angiography (MR) reports (2.4 +/- 1.4 reports per patient). Chi-square and t-tests were used to determine associations between reported valve morphologies (definitely bicuspid, possibly bicuspid, tricuspid, or uncertain) and clinical or patient characteristics. **Results:** We found that more than 40% (84/204) of participants were misclassified in at least one imaging report. The mean interval between misclassification and correct diagnosis was 22 months (1.6 images, Figure 1). TEE (78%), MR (75%) and CT (67%) were more sensitive than TTE (59%) and successfully reclassified 20% (6/29) of participants, but only 14% (29/204) of the entire cohort were imaged using these alternative modalities. Misclassification was linearly associated with age, body mass index, the extent of valve calcification and the severity of aortic valvular stenosis, but was not significantly associated with aortic regurgitation, gender, prior surgical interventions or cusp configuration (left-right versus all others). **Conclusion:** Misclassification of BAV is prevalent, frequently leads to conflicting and/or delayed diagnosis, and is more likely to occur in the most severely affected cases. TEE, CT and MR may increase diagnostic accuracy in up to half of BAV cases but are underutilized. Additional studies are needed to determine if misclassification of BAV patients leads to increased long-term morbidity and mortality.

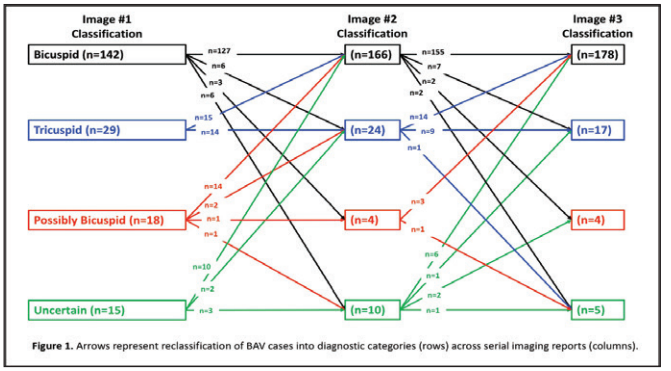

Figure 1. Arrows represent reclassification of BAV cases into diagnostic categories (rows) across serial imaging reports (columns).

P1-15

The Role of Routine Screening Echocardiography in Bioprosthetic Aortic Valves in Adult Congenital Heart Disease

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Background: Valve replacement is common in the estimated two million adults in the United States living with congenital heart disease. Many patients choose bioprosthetic valves to avoid anticoagulation. Aortic bioprosthetic valve function has been shown to

gradually deteriorate over time in older adults, but it is unknown if valve deterioration occurs in a similar, predictable manner in adult congenital heart disease (ACHD) patients. Discrepancy exists even in existing guidelines for acquired heart disease, with AHA/ACC guidelines recommending annual screens starting 10 years postoperatively and European guidelines recommending immediate annual screens. No guidelines currently exist for routine echocardiograms of these valves in ACHD patients. **Methods:** All patients ≥ 18 years of age with bioprosthetic aortic valves who were seen in the Texas Adult Congenital Heart (TACH) clinic after 1995 were considered. Patients were excluded if they did not have at least one echocardiogram associated with a routine follow-up clinic visit. Chart review was performed to determine if patients had cardiovascular symptoms and if any actions were taken (further imaging, cardiac catheterization, surgery) based on either symptoms or echo results. **Results:** N=21 patients met inclusion criteria with diagnoses of bicuspid aortic valve (n=8), congenital aortic stenosis (n=6), ventricular septal defect with aortic insufficiency (n=3), aortic insufficiency with root dilation (n=2), endocarditis (n=1), and truncus arteriosus (n=1). Average age at time of initial valve replacement was 22.7 years (SD 12.4, range 2-40). Over an average follow up time of 14.7 years, n=5 patients (23%) developed symptoms requiring intervention an average of 10.1 years following valve replacement (SD 6.5, range 5.9-21.4) and n=10 patients (45%) had routine echocardiogram findings requiring intervention an average of 7.2 years following valve replacement (SD 5.7, range 0.6-18.2). 57% (n=12) patients were taking aspirin, but this did not correlate with needing intervention. **Conclusion:** The appropriate routine screening echocardiogram schedule is unknown for ACHD patients with bioprosthetic aortic valves. This small, single center study suggests that it may be appropriate to follow these patients with routine screening echocardiograms as changes in echo can appear sooner than symptoms necessitating intervention. However, given this population's distinct differences from adults with acquired heart disease, more data from a multi-center study is needed to reliably tailor recommendations about timing of routine screening.

P1-16

Outcome of Compression of Left Coronary Artery in Patients with Severe Pulmonary Arterial Hypertension Associated with Congenital Heart Diseases

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Background: Pulmonary artery (PA) dilatation is one of the characteristics of long-lasting pulmonary arterial hypertension (PAH). The enlarged PA may compress externally the left coronary artery (LCA), which can leads to potentially left ventricle ischemia and sudden cardiac death. However, such complications of PA enlargement in PAH is not well documented. We explored the prevalence of compression of LCA related to the risk of sudden cardiac death in patients with PAH, and the value of cardiac computed tomography (CT) for the detection. As its treatment option for complete resolution, we suggest open heart surgery including PA angioplasty in PAH-CHD patients with LCA compression. **Methods:** From Jan. 2010 to Feb. 2017, medical records had retrospectively reviewed in PAH adult patients with PA dilatation in short axis view of transthoracic echocardiography, those assessed with heart CT angiography and/ orcine-angiography with cardiac catheterization. **Results:** Total 51 patients (mean age 49±13, 33.3% male) were enrolled. However, complications associated with PA dilatation were found in 18 patients (35.1%): LCA compression were in 18 of 51 (35.1%), almost in patients with CHD (16 of total 18 patients with LCA compression); PA dissection, 1 of 51; and thrombus in PA, 4 of 51. Of total 16 patients with CHD shown LCA compression in CT, only 4 patients revealed critical compression of LCA in coronary angiography. One patient with severe LCA compression underwent invasive coronary angiography and received angioplasty with stent placement at the os of main LCA. In the others, open heart surgery for angioplasty of PA reduction and had done successfully. **Conclusion:** The complications of PA enlargement related to longstanding PAH was high mostly in PAH-CHD. As its treatment for risk eradication, we suggest corrective surgery with main PA angioplasty in PAH-CHD patients with LCA compression. Evaluation of LCA using CT scanning should be considered in PAH patients with dilated PA in regular followup.

P1-17

Coronary Anomalies in Patients with Bicuspid Aortic Valves: Comparison with Tricuspid Aortic Valve

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Background: Patients with bicuspid aortic valve (BAV) may have increased prevalence of coronary anomalies. The relationship between BAV anatomy and coronary anatomy is not well understood. We studied a large cohort of patients with BAV and tricuspid aortic valve (TAV) to investigate coronary anatomy. **Methods:** Retrospective review of patients with surgically excised BAV or TAV was performed from 1994-2015. Clinical notes, echocardiograms, coronary angiograms, and pathology reports were studied. Coronary anomalies were defined as separate ostia of the left anterior descending (LAD) and left circumflex (LCx) arteries, right coronary artery (RCA) from the left cusp, LCx from the right cusp, and LAD from the right cusp. **Results:** 2108 consecutive patients with surgically excised BAV and 1976 consecutive patients with surgically excised TAV were identified. Of these cohorts, 1028 bicuspid patients and 1362 tricuspid patients had preoperative coronary angiogram and were studied further. A left dominant coronary circulation was appreciated in 194 (19%) patients with BAV, and 136 (10%) patients with TAV (p<0.001). Coronary anomalies were identified in 21 (2%) bicuspid and 11 (0.8%) tricuspid patients (p=0.012). Amongst patients with BAV and coronary anomaly, the most common cusp fusion pattern was right-left fusion (n=18, 86%), and most of these valves had present raphe (n=16, 76%). Coronary anomalies in bicuspid patients were separate ostia (n=3, 14%), RCA from the left cusp (n=5, 24%), LCx from the right cusp (n=7, 33%), and LAD from the right cusp (n=6, 29%). Anomalies in the tricuspid group were RCA from the left cusp and LCx from the right cusp, with four patients (36%) each, and LAD from the right cusp (n=3, 27%). No patients with coronary anomaly had an adverse surgical event related to the anomalous coronary artery. **Conclusions:** Patients with BAV have a higher prevalence of left dominant circulation and coronary artery anomalies as compared to TAV patients. The most prevalent BAV anatomy was right-left cusp fusion and present raphe. All patterns of coronary anomaly were represented in BAV patients. Although no patient in our cohort with an anomalous coronary had a related perioperative event, the increased prevalence of coronary anomalies in this group emphasizes the importance of defining coronary anatomy in all BAV patients prior to surgical intervention.

P1-18

Speckle Tracking Echocardiography Detects Early Myocardial Dysfunction in Young Patients with Duchenne Muscular Dystrophy

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Background: Progressive cardiac dysfunction in Duchenne muscular dystrophy (DMD) is a major cause of mortality. Most DMD patients develop cardiomyopathic features by the third decade. Early diagnosis and subsequent medical management may slow disease progression. Subclinical abnormalities in ventricular mechanics have been demonstrated by echocardiography and MRI strain imaging in pre-teen/teenage children with DMD; however, there is no data focused specifically in young children. We hypothesized that LV mechanics assessed by echocardiography are abnormal in young patients with DMD. We evaluated the feasibility of measuring longitudinal and circumferential strain in this group. **Methods:** Patients aged ≤ 9 years with genetically proven DMD and normal ventricular function on initial echocardiogram from 2008-2017 were retrospectively reviewed and compared to age and size matched healthy controls. Longitudinal strain in the apical-2 (A2C), apical 3 (A3C), and apical 4 chamber (A4C) views, global longitudinal strain (GLS), and circumferential strain at the level of the papillary muscles were measured using Tomtec 2D CPA v 4.6. Variables were compared between groups using t-test or Mann-Whitney U test. **Results:** Forty-four DMD patients (age 6.5 +/- 2.2 years) and 46 controls (5.8 +/-2.4 years) were evaluated. Ejection fraction was normal in all patients with DMD but lower than controls (63.3 +/-4% vs 67 +/-4%, p < 0.01). In DMD vs controls, longitudinal strain was measurable in 93% vs 100% of A4C views, 67% vs 83% of A3C views and 71% vs 85% of A2C views respectively. Circumferential strain was calculable in 86% of DMD and 93% of controls. Longitudinal strain in all planes was significantly reduced in DMD when compared to controls (p <0.01 for all): A4C -19.6% [-20.3, -18.9] vs -25.8% [-26.9, -24.6], A3C -19.1% [-20.4, -17.7] vs -25.75% [-26.4, -24] and A2C -19.8% [-20.5, -18.6] vs -25.0% [-26, -23.9]. GLS was reduced in DMD when compared to controls -19.65% [-20.12, -18.25] vs -25.2% [-25.2,-24.4] p <0.01. Circumferential strain was also significantly reduced in DMD vs controls, -25.75% [-32.6, -28.8] vs -30.6% [-26.6, -24.6], p <0.01). **Conclusions:** Despite normal standard measures of left ventricular function, young patients with DMD already have significantly reduced strain when compared to healthy controls. Earlier detection of cardiac involvement in DMD may affect management and disease progression. Larger studies with longitudinal follow-up are necessary to determine the clinical significance of these findings.

P1-19

Prognostic Significance of Tissue Doppler Imaging Derived Myocardial Performance Index in Pediatric Patients with Dilated Cardiomyopathy

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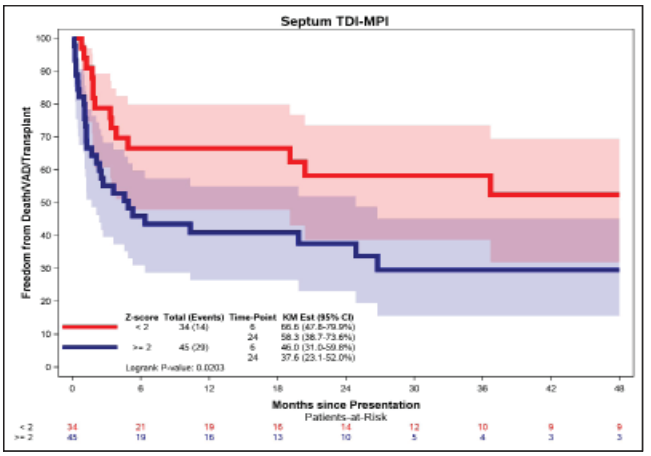
Background: Tissue Doppler (TDI) derived myocardial performance index (MPI) is a marker of global cardiac function. Studies in adults with heart failure have shown that global TDI-derived MPI is a powerful predictor of cardiovascular mortality. However, there is a paucity of data for its use in children. We sought to determine the prognostic significance of TDI-MPI at the time of diagnosis of dilated cardiomyopathy (DCM) in children. **Methods:** Patients aged ≤18 years diagnosed with DCM at our center were included along with age and sex-matched healthy controls. The first echo at diagnosis was analyzed off-line to obtain standard measures of left ventricular (LV) function, Pulse-wave Doppler-derived MPI (PW-MPI), and septal TDI-MPI. Control patients' data were used to produce MPI z-scores. Outcomes included end-points of death, ventricular assist device or transplant. Time to outcome was analyzed using Kaplan-Meier curves stratified

at z- scores ≥ 2. Inter-rater reliability for TDI-MPI was tested in 17 subjects (12 DCM, 5 controls). **Results:** The study included 80 patients with DCM (median age 2 years, 38 males) and 80 controls. During a median follow-up of 194 days (IQR 41 - 846), 37 had event-free survival, 16 underwent a ventricular assist device, 21 cardiac transplant, and 6 died. The mean LV shortening fraction was 13.5% ± 6.5% and LV end diastolic dimension z-score was 5.74 ± 3.60 at diagnosis. There was good inter-observer reliability for TDI-MPI [ICC 0.89 (0.79, 0.94)]. The mean septal TDI-MPI for cases was 0.70 ± 0.23 vs 0.45 ± 0.9 for controls, p <0.001. Event-free survivors had higher LV shortening fraction (p=0.004) and septal S' (p=0.041) compared to those with events. TDI-MPI ≥ 0.63 (z-score ≥ 2) was present in 46% of event-free survivors vs 67.4% with events (p=0.053) and PW-MPI ≥ 0.62 (z-score ≥ 2) was present in 44% of event free-survivors vs 62% with events (p=0.128). Survival analysis showed that those with TDI-MPI z-scores ≥ 2 develop their events significantly earlier than those with z-score < 2 (p=0.020, figure). **Conclusion:** TDI-MPI can be reliably performed in pediatric patients with DCM. A TDI-MPI z-score ≥ 2 at the time of diagnosis may be associated with poorer outcome. Further studies evaluating the use of TDI-MPI in longitudinal follow-up of patients with DCM may be helpful in defining its clinical use.



P1-20

Impact of Early Versus Late Onset Fetal Atrial Level Restriction on Postnatal Transplant-Free Survival in Hypoplastic Left Heart Syndrome: A Single-Center Study of Fetal Echocardiograms

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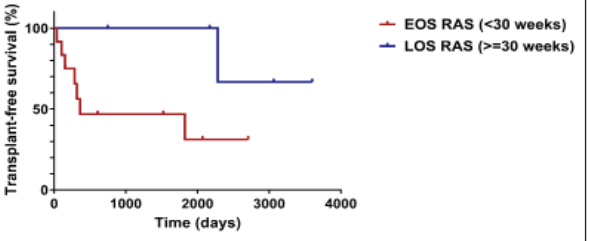
Background - In hypoplastic left heart syndrome (HLHS), restrictive atrial septum (RAS) identified on fetal echocardiogram (ECHO) is associated with poor postnatal survival in part from in utero pulmonary venous hypertension. Diagnosis of atrial level restriction on fetal ECHO has significant implications for prenatal counseling, delivery planning, and postnatal management. We aimed to determine if the gestational age at which atrial level restriction develops, as determined by fetal ECHO, correlates with postnatal outcomes. **Methods** - We performed a retrospective review of serial fetal ECHOs with prenatal diagnosis of HLHS from 1/2004 to 7/2017 combined with respective postnatal records until 1/20/2018. In utero concern for RAS was defined as intact atrial septum, anterograde:retrograde pulmonary vein Doppler ≤3, and/or presence of a decompressing vein. Based on previously published fetal lung maturation data, a gestational age of 30 weeks was a priori chosen to define early-onset (EOS, <30 weeks) RAS versus late-onset (LOS, ≥30 weeks) RAS. Gestational age at the first fetal ECHO with RAS determined EOS RAS or LOS RAS status. Survival analysis was used to evaluate the relationship between timing of ECHO findings of fetal RAS and post-natal transplant-free survival. **Results** - A total of 129 HLHS prenatal courses were reviewed, of which 18 fetuses had ECHO findings of RAS. All 18 patients were delivered successfully and 10 (55.6%) required emergent postnatal interventions, consisting of percutaneous balloon atrial septostomy or emergent stage 1 palliation surgery. The median gestational age of initial fetal ECHO was 23.9 weeks (interquartile range 22.2-26.6 weeks) and the median gestational age of the first fetal ECHO with RAS was 28.1 weeks (interquartile range 24.4-30.4 weeks). A total of 13 patients were considered EOS RAS and 5 patients were LOS RAS. The transplant-free survival curve for patients with fetal ECHO findings of EOS RAS was significantly worse than for those with LOS RAS, p-value<0.05 (figure 1). **Conclusion** - HLHS with RAS diagnosed prenatally has known poor postnatal outcomes. To our knowledge, this is the first study to show that ECHO findings consistent with RAS earlier in fetal development are associated with worse transplant-free survival.

Figure 1 - Transplant-Free Survival of Hypoplastic Left Heart Syndrome Patients with Early-Onset Restrictive Atrial Septum Versus Late-Onset Restrictive Atrial Septum*



*Early-onset (EOS) restrictive atrial septum (ROS) group N=13, Late-onset (LOS) restrictive atrial septum (ROS) Group N=5.
Logrank test p-value=0.048, Breslow test p-value=0.042, Tarone-Ware test p-value=0.040.

P1-21

Early Fetal Echocardiography Can Identify Most Severe Cardiac Pathology

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Background: Fetal echocardiography in early gestation (9-15 weeks) enables detailed assessment of the heart, facilitating diagnosis of congenital heart disease (CHD). Our aim was to define the spectrum of pathology of CHD diagnosed in early pregnancy, examine outcomes, and better define which lesions are missed. **Methods:** We searched our institutional Fetal Cardiology database retrospectively. Patients with pathology who underwent early fetal echo (eFE) at 15 weeks or less were included. Fetal echocardiograms and patient charts were reviewed for diagnosis and pregnancy outcome. **Results:** Of ~600 consecutive pregnancies assessed by eFE, 47 cases with CHD were identified. The median gestational age at first echocardiogram was 13 weeks (range 9-15). Referral indications included increased nuchal translucency (n=20), assisted fertilization (n=9), previous child with CHD (n=2), suspected cardiac pathology (n=7), positive genetic testing (n=2) and other (n=7). In 37 cases, CHD was identified on eFE, including: coarctation (n= 10), hypoplastic left heart (n= 5), tetralogy of Fallot (TOF) (n=5), atrioventricular septal defect (AVSD) (n=2), ectopia cordis (n= 4), double inlet left ventricle (n=2), left atrial Isomerism (n=1), pulmonary stenosis (n= 2), truncus arteriosus with interrupted arch (n= 1), severe bilateral semilunar valve insufficiency (n=1), conjoined twins (at thorax) (n= 1), ventricular septal defect (VSD) (n= 1), corrected transposition (n=1), and supraventricular tachycardia (n=1). Those identified at later gestation included: VSD (n=7), noncritical TOF (n=1), AVSD (n=1), and 2° AV block (n=1). Genetic information was available for 32 patients and chromosomal abnormalities were found in 16 (50%). Seven pregnancies were multiple gestation. Pregnancy termination occurred in 21 (45%) and 6 had intrauterine fetal demise, all 27 of which were identified by eFE. Of these, 10 had either a later fetal echo or autopsy confirmation of the detailed diagnosis. There were 20 live births for which information was available in 19. In 16 patients, including 9 with a diagnosis at eFE, the diagnosis was confirmed postnatally. One patient with suspected coarctation in the 1st and 2nd trimester had a normal aortic arch. Two patients had VSDs that were not detected on fetal echo at any age. **Conclusions:** eFE is effective at identifying most cases of severe CHD. Lesions diagnosed in the first trimester are more likely to be associated with chromosomal anomalies and have a high rate of pregnancy termination and intrauterine fetal demise. CHD not identified by eFE represented non-critical or acquired pathology

P1-22

Left Atrial Strain is Impaired in Childhood Cancer Survivors Exposed to Anthracyclines

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Background: Cancer survivors require regular screening for systolic dysfunction due to cardiotoxicity. We hypothesized that diastolic function as measured by left atrial strain (Ɛ), is 1) impaired in survivors compared to normals, and 2) further impaired in survivors with at least subclinical systolic dysfunction. **Methods:** This was a prospective study of survivors of childhood cancer exposed to anthracycline and a group of healthy controls of similar age and gender proportion. Left atrial Ɛ and strain rate (SR) was averaged from 4- and 2-chamber views with the P-wave as reference. Peak Ɛ and SR was recorded at left atrial contraction (Contract), atrial filling (Fill), and passive emptying (Passive) phases. Mitral E/A and E/e' ratios, left ventricular ejection fraction and global longitudinal strain

(GLS) were collected. Cancer survivors with at least subclinical dysfunction, defined as having abnormal GLS for age group, were compared to survivors with normal GLS. Variables are reported as mean ± standard deviation and compared by Wilcoxon rank sum test. **Results:** There were 56 survivors (age 13.4 ± 5.2 years, 52% male, 6.0 ± 4.9 years from end of treatment) compared to 23 controls (age 12.2 ± 3.9 years, 56% male) (**Table 1**). There was no difference in mitral Doppler ratios. Survivors had lower ejection fraction and the difference in GLS approached significance. All 3 values for left atrial Ɛ, SR-Fill, SR-Passive, and cumulative SR were significantly worse in survivors. There were 17 survivors (30%) with abnormal GLS for age. These patients had worse Ɛ-Fill and Ɛ-Passive, SR-Fill and SR-Passive, and cumulative SR than survivors with normal GLS (**Table 2**). Mitral E/A was lower, though still considered within normal range while E/e' was no different. **Conclusions:** Left atrial Ɛ and SR is impaired in cancer survivors compared to normal and is further deranged in the presence of subclinical systolic dysfunction. Left atrial strain appears superior to mitral Doppler indices and may enhance detection of diastolic dysfunction in this population.

Table 1: Comparison of Cancer Survivors with Healthy Normals

Variable	Survivors (n = 56)	Normals (n =23)	p-value
Age (years)	13.4 ± 5.2	12.2 ± 3.9	0.4
Ejection Fraction (%)	61 ± 4.3	65 ± 3.2	**<0.001**
GLS (%)	-19.8 ± 2.9	-21.6 ± 2.1	0.06
Mitral E/A	2.0 ± 0.5	2.1 ± 0.5	0.5
Mitral E/e'	5.4 ± 1.2	5.4 ± 1.4	0.9
Ɛ-Contract (%)	-10.4 ± 2.9	-12.4 ± 3.8	**0.02**
Ɛ-Fill (%)	41.6 ± 6.3	36.2 ± 6.1	**0.001**
Ɛ-Passive (%)	25.8 ± 5.9	29.2 ± 7.3	**0.04**
SR-Contract	-1.7 ± 0.5	-1.9 ± 0.5	0.06
SR-Fill	1.6 ± 0.4	1.9 ± 0.4	**0.004**
SR-Passive	-2.9 ± 0.7	-3.6 ± 0.8	**0.002**
Cumulative SR	-3.0 ± 0.7	-3.5 ± 0.9	**0.005**

Table 2: Comparison of Cancer Survivors with Impaired GLS and Normal GLS

Variable	Impaired GLS (n = 17)	Normal GLS (n = 39)	p-value
Age (years)	16.4 ± 3.8	12.1 ± 5.2	**0.004**
Time from end-treatment (years)	6.7 ± 5.8	5.2 ± 4.7	0.37
Ejection fraction (%)	57.1 ± 4.4	62.5 ± 3.0	**<0.001**
GLS (%)	-16.4 ± 2.6	-21.3 ± 1.5	**<0.001**
Mitral E/A	1.7 ± 0.4	2.1 ± 0.5	**0.03**
Mitral E/e'	5.0 ± 0.9	5.6 ± 1.2	0.1
Ɛ-Contract (%)	-9.5 ± 2.6	-10.7 ± 3.0	0.26
Ɛ-Fill (%)	32.8 ± 5.4	37.8 ± 5.8	**0.005**
Ɛ-Passive (%)	23.2 ± 5.3	27.0 ± 5.8	**0.03**
SR-Contract	-1.5 ± 0.3	-1.8 ± 0.6	0.11
SR-Fill	1.5 ± 0.3	1.7 ± 0.3	**0.046**
SR-Passive	-2.5 ± 0.5	-3.1 ± 0.8	**0.01**
Cumulative SR	-2.4 ± 0.5	-3.2 ± 0.7	**<0.001**

P1-23

Intervendor Reproducibility of Global Left Ventricular 2D Speckle Tracking Strain in the Structurally Normal Heart in Infants and Children

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Background: Clinical adoption of 2D speckle strain echocardiography (echo) in pediatrics is limited due to the lack of evidence proving its reproducibility. Since the EACVI/ASE industry task force established a new standardization of strain software algorithms, no studies have evaluated intervendor strain reproducibility in children and infants. We evaluated the reproducibility of left ventricular global longitudinal (LVGLS) and global circumferential strain (LVGCS) for mid-myocardial and endocardial layers in pediatric subjects on the two commonly utilized software platforms. **Methods:** Children with structurally normal hearts (n= 53) were prospectively imaged on the GE Vivid E9. The 3 apical LV and 1 parasternal short axis views were optimized for strain. Speckle tracking peak systolic strain was measured in endocardial and mid-myocardial layers on the latest EchoPAC (BT13) and TomTec (Image-Arena 4.6 SP3 CPA 1.2) software. TomTec analysis included acquired (TT) and compressed (TT30) data. Intraclass correlation coefficients (ICC) were compared between GE, TT, and TT30. Intra and interobserver reproducibility was also compared on 22 randomly chosen subjects (intravendor). **Results:** Subjects had normal LVEF > 55% (33/53) or LVEF < 55% (dilated/hypertrophic cardiomyopathy; 20/53) with mean age 8.4 years (range 0.1- 16 yr). Acquisition frame rate mean 82 fps. Feasibility was 96% for LVGLS and 83% for LVGCS. GE mean endo LVGLS and LVGCS were -18.6 SD 4.32 and -17.5 SD 6.3. Mean TT mean endo LVGLS and LVGCS were -15.4 SD 4.32 and -14.7 SD 5.2. In all groups, endo strain was higher than mid. Intervendor reproducibility was good-excellent for both LVGLS and LVGCS (Table) in all layered comparisons. The default intervendor ICCs were at least 0.1 higher in subgroups age < 3 yr, frame rate : HR ratio > 0.7, or EF ≤ 55%. Intra and interobserver reproducibility was good-excellent for all comparisons and slightly higher than the intervendor comparisons. **Conclusions:** Comparison of LV strain analysis between two commonly used software platforms post-EACVI/ASE industry task force recommendations demonstrated good-excellent reproducibility in pediatrics and is slightly higher in LVGLS than LVGCS. Intravendor ICC is higher than intervendor suggesting some variability is present between vendor platforms.

Table

		LV GLS				LV GCS			
Intervendor - same reader (53)		N	Bias	SD	ICC	N	Bias	SD	ICC
Default	GE mid-TT endo	51	0.9	1.9	0.90	44	4.2	4.1	0.82
	GE mid-TT30 endo	51	1.6	2.3	0.88	44	2.5	4.8	0.75
Endo-endo	GE-TT	51	-0.4	2.0	0.89	44	0.1	3.6	0.89
	GE-TT30	51	0.3	2.2	0.89	44	-1.6	5.0	0.78
	TT-TT30	53	-0.6	2.3	0.88	49	1.4	3.9	0.87
Mid-mid	GE-TT	51	-3.2	2.0	0.86	44	-2.7	4.1	0.73
	GE-TT30	51	-2.7	1.9	0.90	44	-2.7	4.4	0.71
	TT30-TT	53	-0.4	2.0	0.86	49	-0.2	2.4	0.90
Intra-observer (22)									
Endo-endo	GE- GE	21	-0.2	1.4	0.96	21	0.0	2.2	0.94
	TT-TT	20	-0.3	1.2	0.96	19	0.0	2.1	0.95
	TT30-TT30	20	0.2	1.4	0.95	19	0.4	1.0	0.99
Mid-mid	GE- GE	21	-0.8	1.4	0.95	21	0.0	1.1	0.99
	TT-TT	20	0.6	3.0	0.85	19	-0.8	1.8	0.98
	TT30-TT30	20	0.2	1.7	0.96	19	0.0	1.7	0.98
Inter- observer (22)									
Endo-endo	GE- GE	19	-0.9	1.3	0.94	17	1.0	3.4	0.88
	TT-TT	20	-1.2	3.6	0.62	18	1.4	2.7	0.92
	TT30-TT30	20	0.1	2.0	0.90	18	0.8	4.0	0.82
Mid-mid	GE- GE	19	-2.0	1.1	0.91	17	-3.3	4.0	0.69
	TT-TT	20	-0.2	1.5	0.88	18	1.2	2.5	0.85
	TT30-TT30	20	-0.4	1.3	0.93	18	1.1	3.6	0.74

P1-24

Hypoplastic Left Heart Syndrome Speck Tracking Echocardiography Atrial Conduit Strain and Strain Rate is Related to Ventricular Diastolic Changes: A Longitudinal Study

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Background: Single ventricle (SV) atrial deformation shows normal maturation changes (increasing conduit and decreasing active atrial strain) with relative impairment of conduit strain (S) and increased reliance on active S for ventricular filling compared to a normal left atrium. These changes may reflect diastolic abnormalities in SV although its relationship with ventricular filling is unexplored. This study aims to study the relationship between atrial and ventricular function in a survival cohort of children with Hypoplastic Left Heart Syndrome (HLHS). **Methods:** Prospectively recruited HLHS patients underwent a functional echocardiogram prior to staged palliation (Norwood-Sano, Glenn and Fontan) and post-Fontan. Atrial area to derive percent active atrial contribution (% active) and speckle tracking echocardiography for atrial and ventricular deformation parameters were measured (GE, EchoPAC). Spearman correlation coefficients assessed relationships between atrial and ventricular deformation parameters. Data is presented as median [IQR]. **Results:** Thirty-seven patients completed staged palliation: Norwood at 8 days [6 - 14], Glenn at 5.7 months [4.8 - 6.0], Fontan at 3.3 years [2.9 - 3.8] and remain alive at median follow up of 8.1 years [5.8 - 9.0]. Expected maturational progress was noted through staged palliation, including an increase in conduit S and strain rate (SR), decreasing active S and SR (Table). This was reflected by progressive decrease in right ventricular late diastolic SR (LDSR). No relationship between atrial function and ventricular function at Pre-Norwood, however, atrial conduit S and SR, active/reservoir strain ratio and % active showed correlations with ventricular LDSR in all subsequent stages [Figure]. **Conclusion:** Maturational changes in HLHS atrial deformation are consistent with previous cross-sectional findings and show the

expected atrial-ventricular relationship. The use of atrial deformation as a tool to detect diastolic dysfunction warrants exploration.

Table: Comparison of various atrial and ventricular deformation variables across stages with Skilling-Mac's test. Data represented as mean [IQR].

	Pre-Norwood	Pre-Glenn	Pre-Fontan	Post-Fontan	p-values
HR (bpm)	156.25 (143.54, 162.60)	119.76 (108.89, 137.93)	93.46 (81.97, 101.52)	103.63 (91.32, 118.34)	**0.001**
IVRT/SQRT RR (msec)	2.07 (1.82, 2.51)	2.29 (1.82, 2.94)	2.15 (1.86, 2.84)	2.22 (1.87, 2.67)	0.43
Longitudinal EDSR (1/s)	1.14 (0.63, 2.67)	1.70 (1.12, 2.11)	1.37 (1.00, 1.70)	1.32 (0.69, 1.89)	0.07
Longitudinal LDSR (1/s)	2.77 (2.25, 3.23)	1.62 (1.17, 2.25)	1.00 (0.78, 1.31)	0.90 (0.63, 1.50)	**0.001**
Circumferential EDSR (1/s)	1.41 (0.79, 1.62)	1.40 (0.82, 1.65)	1.10 (0.83, 1.41)	1.10 (0.85, 1.53)	0.62
Circumferential LDSR (1/s)	1.20 (0.86, 1.63)	1.20 (0.88, 1.76)	0.64 (0.44, 1.09)	0.69 (0.44, 0.93)	**0.001**
Atrial Deformation Variables					
Active Strain (%)	-14.91 (-18.21, -4.63)	-14.16 (-17.50, -6.25)	-10.88 (-16.41, -6.09)	-8.59 (-12.97, -4.88)	**0.03**
Conduit Strain (%)	2.10 (0.72, 3.74)	1.41 (0.12, 3.88)	5.55 (1.78, 7.66)	5.50 (2.44, 9.66)	**0.001**
Reservoir Strain (%)	16.22 (13.28, 22.34)	15.94 (11.72, 25.63)	16.91 (11.81, 27.50)	18.12 (12.38, 25.49)	0.97
Active/reservoir strain ratio	0.84 (0.75, 0.96)	0.92 (0.71, 0.99)	0.72 (0.54, 0.88)	0.59 (0.46, 0.70)	**0.001**
Active Strain Rate (1/s)	-2.88 (-3.57, -1.20)	-2.23 (-2.92, -1.29)	-1.69 (-2.41, -0.91)	-1.50 (-1.94, -0.97)	**0.001**
Reservoir Strain Rate (1/s)	1.82 (1.31, 2.65)	1.60 (1.07, 2.89)	1.39 (1.00, 2.25)	1.59 (1.25, 2.94)	0.02
Conduit strain rate (1/s)	-0.89 (-1.04, -0.42)	-0.47 (-0.69, -0.24)	-0.84 (-1.14, -0.37)	-0.69 (-1.58, -0.37)	0.28
Atrial Fractional Area Change (%)	44.22 (37.64, 53.45)	36.78 (30.99, 43.75)	33.92 (30.48, 41.82)	36.36 (30.00, 50.00)	**0.0001**
% Active	78.17 (69.40, 88.89)	71.88 (62.50, 86.36)	64.55 (48.48, 89.36)	51.61 (41.67, 87.50)	**0.0002**

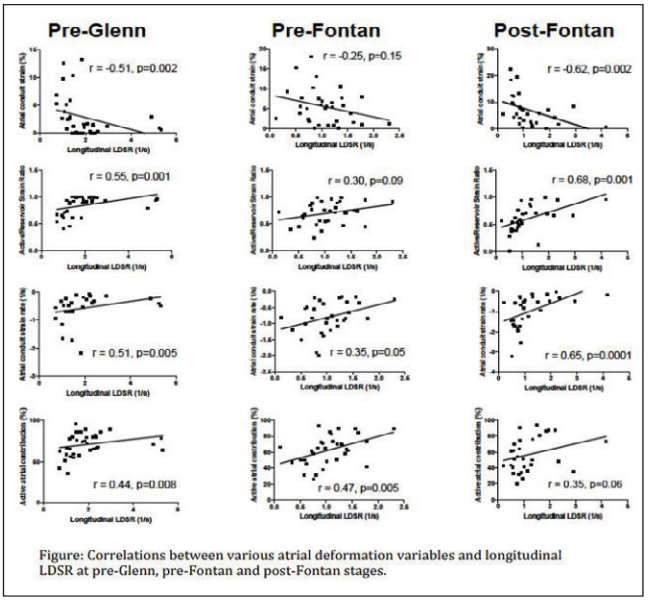

Figure: Correlations between various atrial deformation variables and longitudinal LDSR at pre-Glenn, pre-Fontan and post-Fontan stages.

P1-25

Inter-Vendor Reproducibility of Two-Dimensional Layer Specific Right Ventricular Global Longitudinal Strain in Children

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Background: RV global longitudinal strain (GLS) has emerged as an important technique in the clinical evaluation of RV function. The routine application of RV GLS in pediatrics has been limited by the lack of data on reproducibility and validation between vendors. We investigated the reproducibility of RV GLS between the two commonly used vendors in pediatrics with software versions that utilize the "length of the line" GLS recommended by the EACVI-ASE Strain Task Force. **Methods:** Fifty-three children (age 0-16 yr) with normal intra-cardiac structure underwent studies on GE Vivid E95. An RV focused apical 4-chamber view optimized for strain was analyzed at acquired frame rates in EchoPAC (BT13). DICOM images were uploaded for TomTec analysis (Image-Arena 4.6 SP3 CPA 1.2) at acquired (TT) and compressed frame rate to 30 fps (TT30). Mid-myocardial (mid) and endocardial RV GLS strain was calculated using GE and TomTec software (excluded if more than two segments did not track adequately). GE mid is a full-thickness sampling of the myocardium and TomTec mid is a linear sampling of a mid-myocardial tracing. Inter-vendor reproducibility was tested with bias, SD, and intra-class correlation coefficients (ICC) between GE, TT, and TT30. Intra-reader and inter-reader reproducibility (intra-vendor) was tested on the same platform in 22 randomly chosen subjects. **Results:** For all analyses, feasibility of RV GLS by TT was 85% and by GE was 70%. The mean values of GLS ranged from -20.3% to -25.0%. Intervendor reproducibility was good when comparing acquired frame rate data between the software's default layers (GE mid & TT endocardium) and amongst the same layers (see table). Reproducibility was poor when comparing acquired GE data to compressed TT data. Intra-reader and inter-reader ICCs were excellent. RV GLS ICC was > 0.1 higher in the subgroup with HR < 100 bpm and when ratio of frame rate: heart rate > 0.7. **Conclusion:** RV GLS has reasonable inter-vendor reproducibility when analyzed at acquired frame rates on both systems, but is less reproducible than intra-vendor comparisons. Reproducibility is poor when comparing acquired frame rates on GE to compressed TT data. Comparisons of RV GLS between vendors should be undertaken with caution, especially if there is a mixture of acquired and compressed data.

Inter- vendor and intra-vendor reproducibility of RVGLS					
Inter- vendor (53)		N	Bias	SD	ICC
Default	GE mid-TT endo	37	2.0	4.2	0.64
	GE mid-TT30 endo	37	2.3	7.1	0.35
Endo-endo	GE-TT	37	0.6	4.3	0.63
	GE-TT30	37	1.0	7.4	0.35
	TT-TT30	45	0.1	6.2	0.50
Mid-mid	GE-TT	37	-2.0	3.7	0.67
	GE-TT30	37	-2.7	6.1	0.37
	TT-TT30	45	0.6	5.5	0.46
Intra-reader (22)					
Endo-endo	GE-GE	20	0.1	0.1	0.99
	TT-TT	19	0.4	1.4	0.97
	TT30-TT30	18	-0.4	2.0	0.95
Mid-mid	GE-GE	20	0.5	1.5	0.96
	TT-TT	19	-0.2	1.0	0.98
	TT30-TT30	18	-0.3	1.3	0.97
Inter-reader (22)					
Endo-endo	GE-GE	16	0.0	1.6	0.94
	TT-TT	18	-0.1	1.4	0.95
	TT30-TT30	17	0.3	4.4	0.74
Mid-mid	GE-GE	16	-1.4	2.0	0.88
	TT-TT	18	0.0	1.5	0.93
	TT30-TT30	17	-0.5	2.2	0.95

P1-26

Ventricular Function in a Large Cohort of Healthy, Term Newborns Assessed by Advanced Echocardiography: Establishment of Normal Values and Z-scores

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Background: There is a paucity of published data presenting normal values for ventricular function in newborns. The Copenhagen Baby Heart Study (CBHS) is an ongoing multicenter, prospective, population study of newborns (n=25,000) in Copenhagen, Denmark, including systematic transthoracic echocardiography (TTE) and electrocardiography. The purpose of this substudy was to establish echocardiographic normal values and calculate Z-scores for ventricular functional parameters in newborns assessed by advanced echocardiography (Tissue Doppler imaging and 2D Speckle Tracking). **Methods:** We included healthy, term newborns from the CBHS who had a comprehensive TTE examination performed within 14 days of birth without any signs of structural or functional cardiac abnormalities. Measurements were obtained offline, according to the American Society of Echocardiography's guidelines. BSA was calculated using the Haycock formula. Z-scores are being developed based on the most adequate model for each echocardiographic parameter and are presented here as preliminary results. **Preliminary results:** Four hundred newborns (53% males) with gestational age of (mean±SD) 40.2±1.2 weeks and age, weight, and length at examination of 11±3

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days, 3.7±0.5 kg, and 53±2 cm were included. Values for conventional and advanced echocardiographic measurements of ventricular function are presented as mean ±SD or median values (interquartile range) as appropriate (*Table 1*). Results for selected parameters according to BSA are illustrated (*Figure 1*). **Conclusion:** Preliminary normative data for echocardiographic measurements of ventricular function in 400 healthy, term newborns are presented. Further analysis will be performed. The final results will contribute substantially to a field where available data are limited.

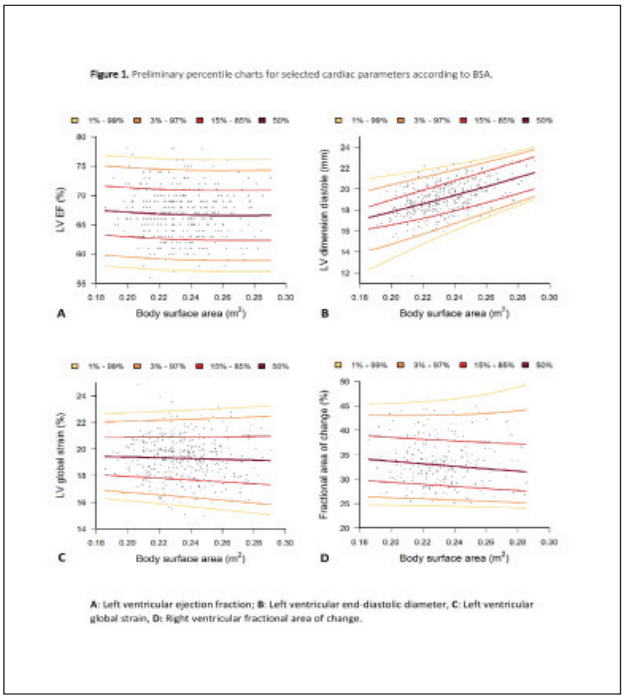

Table 1. Conventional and advanced echocardiographic measurements of ventricular function

	Parameter	View and modality	Value	Unit
Systolic function				
Left ventricle	*Shortening fraction*	Parasternal long-axis M-mode	35±3	%
	Ejection fraction	Parasternal long-axis M-mode	67±4	%
	Simpsons biplane ejection fraction	Apical 4- and 2-chamber 2D	59.1±2.8	%
	s' septum	Apical 4-chamber Tissue Doppler	4.6±0.6	cm/s
	s' lateral wall	Apical 4-chamber Tissue Doppler	4.8±0.6	cm/s
	Global longitudinal strain		19.3±1.6	%
Right ventricle	*Tricuspid annular plane systolic excursion*	Apical 4-chamber M-mode	9.5 (8.8; 10.3)	mm
	Fractional area change	Apical 4-chamber 2D	33±5	%
	s' free wall	Apical 4-chamber Tissue Doppler	5.5 (4.5; 6)	cm/s
	Peak systolic longitudinal strain	Apical 4-chamber 2D	23±4	%
Diastolic function				
Left ventricle	*Mitral valve E-wave*	Apical 4-chamber pulsed Doppler	57.5±9	cm/s
	Mitral valve A-wave	Apical 4-chamber pulsed Doppler	54.9±9.4	cm/s
	e' (septum)	Apical 4-chamber Tissue Doppler	5.7±0.8	cm/s
	Mitral valve E:e' ratio (septum)	Apical 4-chamber Tissue Doppler	10 (8.7; 11.3)	
	e' (lateral wall)	Apical 4-chamber Tissue Doppler	7±1	cm/s
	Mitral valve E:e' ratio (lateral wall)	Apical 4-chamber Tissue Doppler	8.3 (7.2; 9.4)	
Right ventricle	*Tricuspid valve E-wave*	Apical 4-chamber pulsed Doppler	42 (36; 48)	cm/s
	Tricuspid valve A-wave	Apical 4-chamber pulsed Doppler	51 (45; 58)	cm/s
	e'	Apical 4-chamber Tissue Velocity	6.3 (5.6; 7)	cm/s
	e':a' ratio		0.9 (0.8; 1.1)	
	Tricuspid valve E:e' ratio		6.5 (5.8;7.8)	

P1-27

Right Atrioventricular Function and Exercise Performance in Youth with Repaired Tetralogy of Fallot

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Background: Right ventricular (RV) diastolic function in patients with repaired Tetralogy of Fallot (rTOF) has been associated with worse functional status. We sought to investigate the changes in right atrial (RA) function and RV diastolic function from rest to peak exercise and the relationship of these changes with exercise capacity and RV systolic function in youth with rTOF. **Methods:** Subjects presenting for cardiopulmonary exercise test underwent rest and peak exercise research echocardiograms. Peak right atrial longitudinal strain (RALS) was used as a measure of right atrial reservoir function. Tricuspid myocardial velocities and inflow Doppler (E and A) velocities were used as measures of diastolic function. Peak RV longitudinal strain (RVLS) was used as a measure of systolic function. Exercise test measures included the percent-predicted maximum oxygen consumption (%mVO2), percent-predicted maximum work, and oxygen pulse. The median RALS was used to divide patients into low and high RALS groups. Differences from rest to peak exercise were examined using within-person paired T-tests. **Results:** We enrolled 32 patients (age 16.4 ± 4.9 years, 66% male). RALS and Tricuspid inflow E and A velocities increased significantly from rest to peak exercise. Higher peak RALS was associated with lower %mVO2 and with greater oxygen pulse. There was no association of change in other diastolic parameters with exercise parameters. Greater RALS at rest was associated with greater RVLS at rest. **Conclusions:** In patients with rTOF, RA function is directly associated with RV systolic function, at rest. At peak exercise, increased RA reservoir function is associated with worse exercise performance. An increase in RA reservoir function during exercise could be a result of several factors, including volume loading from pulmonary insufficiency and impaired RV relaxation. Further investigation is needed to understand the complex right atrioventricular interactions and their role in exercise performance in this patient population.

Echocardiographic Parameters			
	Rest*	**Peak***	**P-Value**
Tricuspid E Velocity (m/s)	0.66 (0.41-1.17)	0.9 (0.10-1.39)	0.002
Tricuspid A Velocity (m/s)	0.38 (0.16-0.54)	0.7 (0.56-0.90)	0.010
E/A Ratio	1.7 (1.0-6.16)	1.16 (1.08-1.64)	0.18
Tricuspid peak E' Velocity (m/s)	0.09 (0.05-0.78)	0.13 (0.06-0.2)	0.53
Tricuspid Peak A' Velocity (m/s)	0.06 (0.03-0.61)	0.11 (0.05-0.2)	0.38
Tricuspid E/E' Ratio	6.7 (2.5-15.4)	6.67 (0.83-13.7)	0.55
RALS (%)	32.6 (13.9-53.4)	40 (4.8-111)	0.015
RVLS (%)	16.6 (8 – 27)	13 (5 – 28)	0.0042

Analysis of Exercise Parameters			
Predictor	**Outcome**	**Coefficient#**	**P-Value**
RALS rest (%)	Percent-predicted maximum VO2	0.14 (-0.62, 0.90)	0.71
	Percent predicted maximum Work	-0.035 (-0.99, 0.92)	0.94
	Oxygen Pulse	-0.13 (-0.27, 0.0042)	0.057
RALS peak (%)	Percent-predicted maximum VO2	-0.33 (-0.65, -0.0021)	0.049
	Percent-predicted maximum Work	-0.15 (-0.54, 0.24)	0.43
	Oxygen Pulse	0.071 (0.012, 0.13)	0.020

Analysis of RV Strain			
Predictor	**Outcome**	**Coefficient#**	**P-Value**
RALS rest (%)	RVLS rest	3.81 (0.17, 7.45)	0.041
	RVLS peak	0.95 (-3.04, 4.94)	0.63
	RVLS change^	-2.87 (-6.15, 0.42)	0.085
RALS peak (%)	RVLS rest	0.35 (-3.29, 3.99)	0.85
	RVLS peak	1.37 (-2.62, 5.35)	0.49
	RVLS change^	1.02 (-2.27, 4.30)	0.53

**Results reported as median (range)*
#Results reported as regression coefficients with 95% Confidence Interval (CI)
^Difference between RVLS peak and RVLS rest
P value <0.05 is statistically significant

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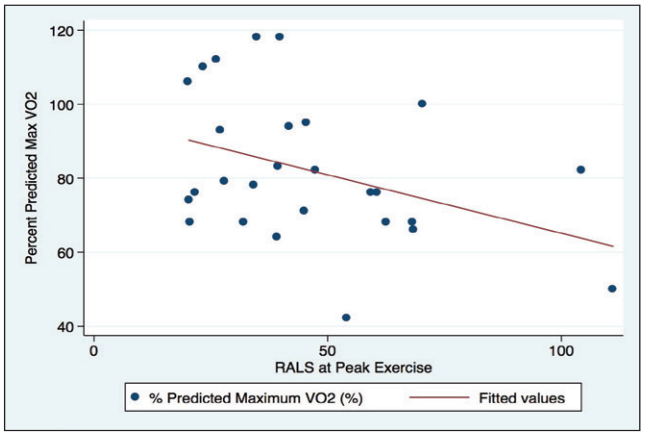

P1-28

Pressure Recovery Corrected Doppler Gradients Accurately Predict Subsequent Catheterization Gradients in Congenital Pulmonic Valve Stenosis: Doppler Echocardiography and Cardiac Catheterization Correlative Study

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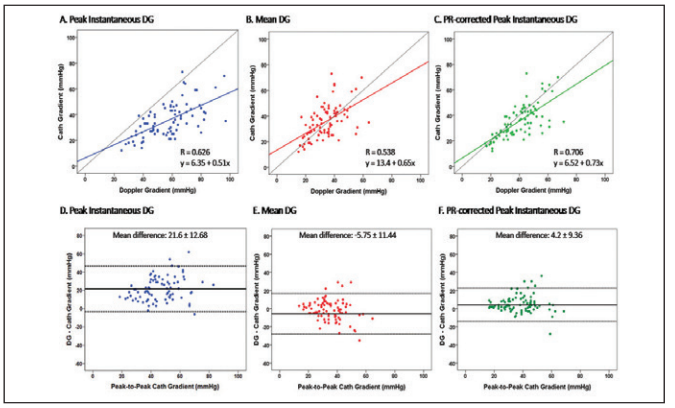
Background: In congenital pulmonic stenosis, suboptimal agreement between Doppler-derived gradients and catheterization gradients may lead to inaccurate classification of disease severity and inappropriate referrals for catheter intervention. Our aim was to investigate if adjusting Doppler gradients for pressure recovery (PR) accurately predicted subsequent catheterization gradients. **Methods:** Retrospective, single-center cohort study of 86 pediatric patients with pulmonic stenosis who underwent echocardiography and subsequent catheterization within 1 month. Peak-instantaneous (PIG) and mean (MIG) pulmonary valve Doppler gradients were recorded. PR (mmHg) was calculated as PR = 4Vcw2 x (2 x EOA/POA) x (1-EOA/POA), where Vcw is the continuous-wave peak velocity, EOA is effective orifice area (stroke volume/velocity-time integral), POA is the pulmonary cross-sectional area (π x radius2). The PR-corrected peak Doppler gradients (PRcPIG) were calculated by (PIG - PR). Doppler gradients were compared with the peak-to-peak systolic gradient (P-PG) at catheterization by Bland-Altman and regression analysis. **Results:** Baseline demographics, and the various Doppler and cath gradients are shown in Table 1. As shown in Figure 1, PRcPIG had the best correlation with P-PG (r=0.71) and smallest bias with narrowest limit of agreement (4.2 ± 9.36 mmHg). PIG overestimated and MIG underestimated the subsequent P-PG. ROC analysis for a P-PG of ≥ 30 mmHg revealed a larger area under the curve for the PRcPIG (0.88) compared to the PIG (0.81) and the MIG (0.77). PRcPIG gradient of ≥ 32 mmHg detected a P-PG ≥ 30 mmHg with 89% sensitivity and 59% specificity. **Conclusions:** In congenital pulmonic stenosis, PRcPIG, most accurately predicts P-PG at subsequent catheterization. Correcting Doppler gradients for PR may improve classification of lesion severity and reduce unnecessary referrals for catheter intervention.

Demographic, outpatient Doppler gradient, and Cath gradient data	
	Mean ± SD
Age (years)	4.34 ± 6.01
Gender (female, n (%))	45 (52%)
Height (cm)	89.5 ± 42
Weight (kg)	21.6 ± 26.2
Catheter Peak-to-Peak gradient (P-PG)	35.4 ± 12.9
Mean Doppler gradient (MIG)	32.4 ± 9.6
Peak instantaneous Doppler gradient (PIG)	56.9 ± 15.9
Maximum instantaneous Doppler gradient, corrected for pressure recovery (PIGcPR)	39.6 ± 12.5



P1-29

Congenital Heart Abnormalities Associated with Loss of Function Filamin A Gene Mutations

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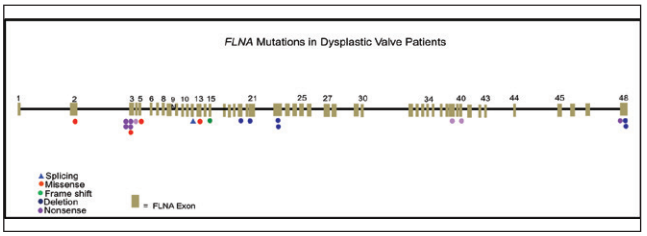
Loss of function (LOF) mutations in the Filamin A (FLNA) gene, which encodes an actin binding protein, are associated with thoracic aortic aneurysm in young patients and also a brain disease, called X-linked periventricular nodular heterotopia (Chen et al, 2018, AJMG 176:337-35). However, other types of congenital heart disease (CHD) associated with LOF FLNA mutations have been less well-defined, and their frequency unknown. Therefore, from our FLNA registry of 69 study patients and 66 literature patients with known cardiac assessment, we characterized the range and frequency of cardiac structural abnormalities. All but 4 patients had an echocardiogram. RESULTS: 135 patients (107 F, 28 M, median age 19 yrs, > 50% ≤ 21 yrs, range 0-71 yrs) with LOF FLNA mutation formed our cohort. 95 patients had CHD, which included ventricular septal defect (n=14), atrial septal defect (n=12), patent ductus arteriosus (PDA) (n=30), and valve disease (n=66). 47 of 95 CHD patients (49%) had ≥ 1 myxomatous/dysplastic or dysfunctional valve, with the mitral valve being most commonly affected (25/66); 15 patients had mitral valve prolapse (MVP). The aortic valve was frequently regurgitant, with mild to severe regurgitation present in 27 subjects; only 4 had a bicuspid aortic valve. 9 patients had a dysplastic/dysfunctional tricuspid valve, and 8 had a dysplastic pulmonic valve. Serial follow-up over >15 yrs found at least 2 patients who developed MVP over time, during their teenage years. Genomic locations of exonic FLNA mutations associated with valve disease are displayed below. Non-valvular CHD included 30 patients with a PDA, of which 16 required surgical ligation during early childhood. CONCLUSIONS: In this largest cohort of LOF FLNA patients, CHD was present in 70.4% of patients. Given the frequency of structural cardiac abnormalities, echocardiography should be considered in neonates with PVNH with LOF FLNA mutations. Children and adults with FLNA mutations should have serial echocardiograms to assess change in their disease.



P1-30

Right Ventricular and Atrial Diastolic Function and their Relation to Impaired Exercise Capacity in Ebstein Anomaly

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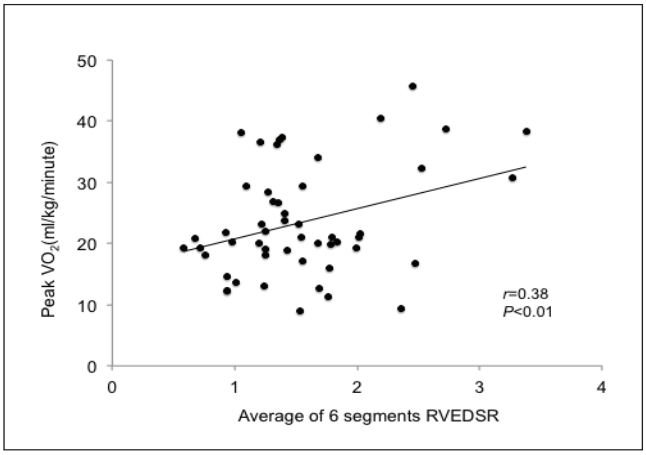
Background: Right ventricular (RV) diastolic and right atrial (RA) function are poorly characterized in patients with Ebstein anomaly but may influence functional capacity. We hypothesized that RV & RA diastolic dysfunction are present and related to exercise intolerance in Ebstein anomaly. **Methods:** Ebstein anomaly patients and age & institution matched controls were recruited at 2 institutions: adult patients prospectively in Munich

and children retrospectively in Toronto. We used echo, cardiac magnetic resonance imaging and exercise testing to investigate RV diastolic and systolic function, RA function, ventricular volumes, and their relation to exercise capacity (VO_2). **Results:** 109 Ebstein anomaly patients and 106 controls were studied. Ebstein anomaly patients had RV diastolic dysfunction vs. controls as manifested by reduced tricuspid E/A ratio, RV filling time and global early (RVEDSR) and late (RVEDLR) diastolic strain rate and increased tricuspid E/E' ratio, isovolumic relaxation time and RV myocardial performance index (Table). The average of 6 RV segments RVEDSR correlated weakly with peak VO_2 (r= 0.34, P<0.01, Fig), RV EF (R=0.41, P<0.01), indexed RV end systolic volume (r=-0.29, P<0.05), left ventricular (LV) EF (r=0.33, P<0.05) and indexed LV end systolic volume (r= -0.30, P<0.05). Ebstein anomaly patients had impaired RA reservoir, conduit and pump function which were associated with peak VO_2 (r= 0.55, P<0.001 for reservoir function). Diastolic parameters worsened with age in Ebstein anomaly more than in controls. **Conclusions:** Ebstein anomaly patients have RV diastolic and RA dysfunction associated with impaired biventricular systolic function and exercise capacity. Diastolic dysfunction in Ebstein anomaly seems to worsen over time, over and above age-related changes.

Echo, MRI and Metabolic Exercise Testing in Ebstein Patients					
	Ebstein (n=109)	n	Control (n=106)	n	*P*-value
Echocardiographic findings					
Tricuspid E (cm/s)	0.67±0.22	78	0.55±0.11	84	<0.001
Tricuspid A (cm/s)	0.55±0.23	78	0.36±0.10	84	<0.001
Tricuspid E/A ratio	1.3±0.53	78	1.7±0.51	84	<0.001
Tricuspid E' (cm/s)	0.11±0.047	70	0.12±0.022	67	0.057
Tricuspid A' (cm/s)	0.090±0.042	70	0.08 ±0.040	71	0.2
Tricuspid E/E' ratio	7.8±5.2	53	4.8±1.2	57	<0.001
Isovolumic relaxation time (msec)	49±41	56	20±14	41	<0.001
RV MPI	0.36±0.21	59	0.13±0.097	50	<0.001
RV filling time (msec)	374±113	81	461±119	84	<0.001
% RV filling time	48±7.8	81	56±5.6	84	<0.001
Average of 6 segments RVEDSR (s-1)	1.6±0.60	57	1.9±0.58	55	<0.001
Average of 6 segments RVLDSR (s-1)	0.82±0.46	57	1.1±0.32	55	<0.001
RA total emptying fraction	0.23±0.088	82	0.41±0.095	89	<0.001
RA passive emptying fraction	0.13±0.094	82	0.29±0.10	89	<0.001
RA active emptying fraction	0.12±0.083	82	0.16±0.10	89	<0.05
MRI and Exercise test findings					
Indexed RV end diastolic volume(ml/m2)	147±65	67			
Indexed RV end systolic volume(ml/m2)	76±39	67			
RV EF(%)	49±11	67			
Indexed LV end diastolic volume (ml/m2)	58±11	67			
Indexed LV end systolic volume (ml/m2)	24±8	67			
LV EF(%)	59±10	67			
Peak VO2 (ml/kg/minute)	23±9	66			



P1-31

Systematic Cycles of Testing and Training Can Improve Reproducibility and Decrease Variability in Ejection Fraction Measurement in a High Volume Pediatric Echocardiography Laboratory

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Background: Reliable echocardiographic (echo) assessment of left ventricular (LV) size and ejection fraction (EF) is critical to the management of multiple medical conditions in children. Studies suggest that >10% variation can occur in EF measurement by 2-dimensional echo due to inter-observer variability (IOV). We hypothesized that IOV for LV EF and volumes by the 5/6 area -length method can be improved by quality improvement interventions designed to standardize image acquisition and measurement. **Methods:** Sonographers were graded on image acquisition (maximum score = 10) by review of 3 random studies performed and on measurement technique (maximum score =12) by measuring EF on the same 5 sets of images blinded to each other. Images varied in technical difficulty and included cardiomyopathy (dilated and hypertrophic) and pulmonary artery hypertension. Data were obtained at baseline (phase I), after a general teaching session (phase II) and following a second teaching session along with individual training for sonographers with lower score (phase III). To assess sustainability of the improvement, data were again obtained 6 months after the last intervention (phase IV). To assess IOV, difference from an expert reader (imager cardiologist) was computed for variables [LV length, area, volume (in systole and diastole), and EF] by calculating percent error. For EF, absolute difference from expert was also compared. General linear model with post-hoc comparisons were used to compare the phases. **Results:** Nineteen sonographers participated (pediatric echo experience < 1- > 20 years) in the study. There was improvement in the acquisition and measurement scores across the time frame of the study (table 1). Table 2 shows the percent error for variables. Absolute EF difference from expert was lower post intervention. **Conclusions:** IOV for assessment of EF and LV volumes by 5/6 area-length method could be significantly improved through focused teaching interventions and the improvement was sustained 6 months post intervention.

Table 1 : Sonographer Scores			
Phase	**Measurement score (max =12 points)**	**Acquisition score (max=10 points)**	**Total score (max =22 points)**
I	9.33 ± 1.36	8.32 ± 1.55	17.65 ± 2.32
II	10.29 ± 0.96**	9.47 ± 0.64***	19.77 ± 1.32***
III	10.98 ± 0.72***	9.42 ± 0.48***	20.40 ± 0.85***
IV	11.13 ± 0.71***	9.02 ± 0.91*	20.14 ± 1.37***
* denotes significant change from baseline/phase I (* p<0.05, **p<0.01, ***p<0.001)			

Variable	**Table 2 : Percent error from expert reader (difference/average)**			
	Phase I n = 100	**Phase IIn = 95**	**Phase IIIn = 95**	**Phase IV n =95**
LV length (diastole)	4.1 ± 3.6	2.8 ± 2.0***	2.6 ± 2.2***	2.9 ± 2.2***
LV length (systole)	6.3 ± 6.0	3.6 ± 2.8***	3.1 ± 2.9***	3.7 ± 4***
LV area (diastole)	9.1 ± 7.4	6.6 ± 6.5*	6.4 ± 9.4*	5.3 ± 5.8***
LV area (systole)	12.2 ± 8.9	12.0 ± 11.8	8.4 ± 12.5*	7.5 ± 8**
LV volume (diastole)	10.7 ± 8.4	7.6 ± 6.3**	7.4 ± 9.7**	6.9 ± 6.4**
LV volume (systole)	14.5 ± 10.5	13.2 ± 11.6	9 ± 11.8***	10.1 ± 9.2**
LV EF (percent error)	17.1 ± 17.3	16.4 ± 19.9	15.2 ± 16.6	10.8 ± 13.5*
EF difference from expert reader	5.9 ± 4.7	4.7 ± 3.7*	4.4 ± 3.3**	3.9 ± 3.4***
* denotes significant change from baseline/phase I (*p<0.05, **p<0.01, ***p<0.001)				

P1-32

Inter-Observer and Inter-Vendor Variability in Strain Measurements in Patients with Single Right Ventricular Anatomy

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Background: Myocardial strain offers new insights into ventricular performance. However, inter-vendor and inter-observer variability have not been evaluated in patients with single, right ventricular (sRV) physiology. **Methods:** Echocardiograms from 79 pts with sRV (116 separate studies) were prospectively evaluated after IRB approval and consenting process. All pts had undergone Glenn and/or Fontan palliation. Longitudinal strain was assessed in apical 4 chamber (4LS) and subcostal inflow/outflow (IO) views. Circumferential and radial strain was assessed in the short axis plane. Results were analyzed using both Velocity Vector Imaging (VVI, Seimens, Munich) and Automated Functional Imaging (AFI, General Electric, Boston) software. Paired "inter-observer" analyses were performed in a subset of the pts for each type of strain measurement. **Results:** Adequate 4LS assessments were obtained in most sRV pts (114 /116), but IO, circumferential and radial curves were suboptimal more frequently (see Table 2). Inter-observer variability data (mean difference) for the various strain measurements are shown in Table 1. Mean values and correlations between the two vendor software packages for 4LS, global circumferential strain, global radial strain, and average anterior IO and inferior IO wall longitudinal strain are also reported in Table 1. Both vendor software packages showed good inter-observer reproducibility for longitudinal and circumferential strain values. More variation was seen in radial strain values with both AFI and VVI software. There was reasonable inter-vendor correlation for sRV global circumferential strain values. However, correlation between vendor packages was ≦ 0.6 for all other assessments. **Conclusion:** While there was little inter-observer variation in sRV strain values using either analysis package; the inter-vendor correlation remains poor, with the exception of global circumferential strain. At this time, serial evaluations of longitudinal and radial myocardial strain in sRV should be made using the same analysis software.

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Table 1. Average inter-sonographer and inter-vendor variability for VVI and AFI.

Strain Difference (%)	n		Mean Difference		Limits of Agreement		
VVI Apical 4-Chamber Longitudinal	68		-0.2 ± 3.0		(-6.0, 5.7)		
VVI IO Anterior	53		0.3 ± 5.9		(-11.3, 12.0)		
VVI IO Inferior	53		1.1 ± 4.7		(-8.0, 10.2)		
VVI Global Circumferential	50		-0.18 ± 3.5		(-7.1, 6.7)		
VVI Global Radial	42		-1.3 ± 17.1		(-34.8, 32.2)		
AFI Apical 4-Chamber Longitudinal	55		-0.3 ± 2.0		(-4.2, 3.6)		
AFI IO Anterior	37		-1.3 ± 4.7		(-10.5, 7.9)		
AFI IO Posterior	43		-0.8 ± 5.4		(-11.3, 9.8)		
AFI Global Circumferential	26		0.3 ± 3.5		(-6.54, 7.1)		
AFI Global Radial	33		1.05 ± 24.7		(-27.8, 29.9)		
Strain (%)	**n**	**VVI Mean**	**Mean Difference**	**AFI Mean**	**Limits of Agreement**	**Spearman Correlation**	**95% CI**
Apical 4-Chamber Longitudinal	114	-14.6 ± 3.4	2.0 ± 3.1	-16.6 ± 3.4	(-4.0, 8.0)	0.6	(0.5, 0.7)
IO Anterior	88	-12.8 ± 4.0	-0.7 ± 5.5	-12.2 ± 5.6	(-11.4, 10.1)	0.4	(0.2, 0.6)
IO Posterior	94	-17.6 ± 4.8	0.4 ± 4.7	-18.0 ± 4.6	(-8.7, 9.5)	0.6	(0.4, 0.7)
Global Circumferential	71	-15.4 ± 4.4	-1.4 ± 3.2	-14.0 ± 4.8	(-7.7, 5.0)	0.8	(0.7, 0.9)
Global Radial	80	31.1 ± 13.5	6.2 ± 16.6	24.9 ± 11.3	(-26.4, 38.8)	0.2	(-0.1, 0.4)

P1-33

Pulmonary Artery Acceleration Time is a Sensitive Marker for Assessing Pulmonary Artery Resistance and Capacitance in Pulmonary Hypertension

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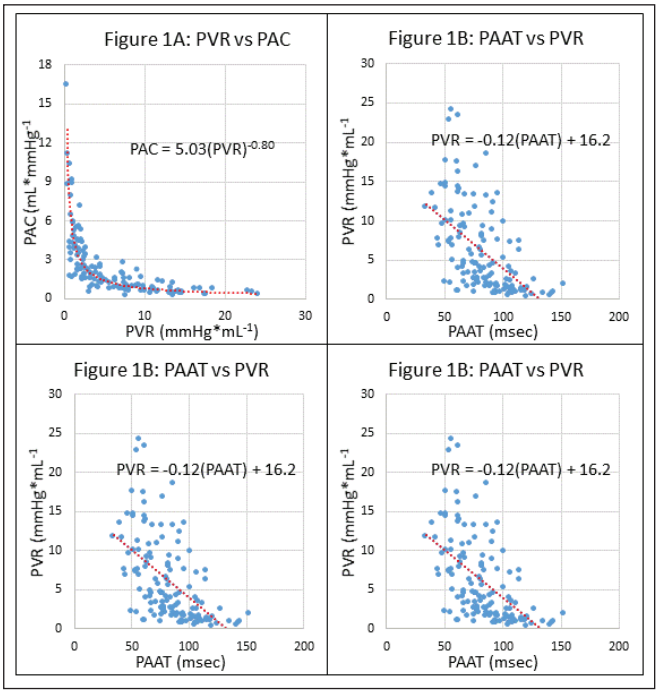
Background: Right ventricular dysfunction and its relationship to the afterload of the pulmonary vasculature independently predicts survival regardless of pre-capillary or post-capillary etiology. The static and dynamic components of afterload are described by assessing systolic pulmonary artery pressure (SPAP), pulmonary vascular resistance (PVR), and pulmonary arterial capacitance (PAC). Accurate measurements of these values require invasive assessment via catheterization limiting usage in a clinical setting. We assessed whether non-invasive Doppler echocardiographic measurements adequately estimate these components of afterload regardless of etiology and severity. **Methods:** We retrospectively isolated catheterizations with an echocardiogram performed within 1 month with no post-tricuspid valve shunts or stenoses in the pulmonary circulation. We collected echocardiographic indices of pulmonary artery acceleration time (PAAT) and right ventricular ejection time (RVET). From catheterization data, we collected SPAP, PVR and PAC. Linear regression for PAC with each of the echocardiographic measurements was performed using SPSS version 25. **Results:** We identified 110 patients with 140 diagnostic catheterizations. Those with pulmonary hypertension (PH, n=70 catheterizations) were divided by etiology of PH (congenital heart disease: 31, left heart disease: 17, idiopathic: 13, chronic lung disease: 6, other: 3). There was an inverse relationship between resistance and capacitance modeled by the formula $PAC=5.03*(PVR)^{-0.80}$ (Figure 1A). PAAT has a moderate inverse relationship with PVR as well as SPAP and a direct relationship between PAAT and PAC (Figure 1B-D, R values in Table 1). RVET showed limited correlation to cath indices. **Conclusion:** PAAT is able to provide an estimation of SPAP, PVR, and PAC in a variety of diagnoses and afterload. PAAT, therefore, is an easily employed and incorporates both dyanmic and static components to right ventricular afterload.

Table 1 shows R values comparing PAAT and RVET to SPAP, PVR, PAC

	Linear Regression Pearson correlation R value
PAAT: PVR	0.51
PAAT:PAC	0.60
PAAT:SPAP	0.30
RVET:PVR	0.34
RVET:PAC	0.47
RVET:SPAP	0.10



P1-34

Differential Right Ventricle Remodeling In Response to Increased Pressure Versus Volume Loading: A Serial Experimental Study

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Background: Right ventricular (RV) dysfunction from increased pressure or volume loading are important determinants of morbidity & mortality in children with congenital & acquired heart disease. Moreover, treatment of one (e.g. pulmonary stenosis) can cause the other (e.g regurgitation) but the benefits versus risks of that tradeoff are incompletely characterized. We sought to compare the impact of pure increased RV pressure versus volume loading on RV size, function and fibrosis in a rat model. **Methods:** Pulmonary artery banding (PAB): Via thoracotomy, a suture was tied around the main pulmonary artery (MPA) and an 18-G needle placed alongside the MPA. Removal of the needle leaves a standardized fixed constriction. Pulmonary regurgitation (PR): Via thoracotomy and MPA, puncture & suture of the pulmonary leaflets produced severe PR. Shams underwent thoracotomy. 5-weeks after PAB & 12-wks after PR, RV size & function were examined by echo. After sacrifice, RV myocardium was stained with picrosirius red for quantification of fibrosis expressed as % collagen area. **Results:** 22 male Sprague-Dawley rats (250 gr, Sham n=6; PAB n=10; PR n=6) were studied. RV systolic pressure was 69.9±20.5mmHg in PAB and 29.4±3.0 in PR rats. PAB & PR rats developed similar RV dilatation (RV end diastolic area index (RVEDAi) 9.7±2.7 vs. 9.8±1.0 cm^2/m^2, p=ns); but end systolic area (RVESAi) was larger in PAB vs. PR (Fig). Hence, RV fractional area change (FAC) was lower in PAB rats (21.1±4.7 vs. 46.3±9.7%, p<0.001). RV Fibrosis was higher in PAB vs. PR rats (11.5±3.8 vs. 5.9±0.7%, p=0.003). A positive linear relationship was observed between peak RV pressure and RVESAi and the burden of RV fibrosis; while a negative linear relationship was observed between RV fibrosis and RV FAC and tricuspid annular plane systolic excursion (Fig). **Conclusion:** RV pressure vs volume loading induces similar RV dilatation, but more systolic dysfunction, in relation to RV fibrosis burden. The results suggest that pulmonary stenosis should be treated aggressively, even at the expense of PR, if unavoidable.

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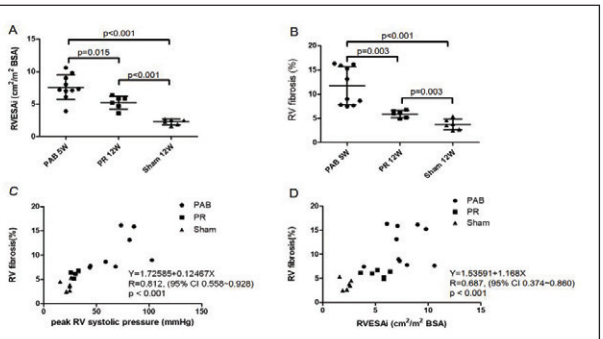

Figure. Echocardiographic right ventricular (RV) end systolic area index (RVESAi) was compared between pulmonary artery banding (PAB, n=10), pulmonary regurgitation (PR, n=6) and Sham (n=6) rats **(A)**. RV fibrosis (% picro-sirius red stained area) was compared between PAB, PR and Sham groups **(B)**. Correlation between RV fibrosis area and peak RV systolic pressure (C). Correlation between RV fibrosis area and RVESAi (D). Bars represent mean ± standard deviation.

P1-35

Fetal Echocardiographic Predictors of Two Ventricular Repair in Prenatally Diagnosed Atrioventricular Canal Defects with Varying Degrees of Balance

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Background: Atrioventricular canal defects (AVCD) are frequently diagnosed in the fetus and present with varying degrees of balance with regard to ventricular size and inflow. The range in severity of LV or RV hypoplasia in unbalanced AVCDs (uAVCD) makes it challenging to predict whether a biventricular (2V) repair or single ventricle (1V) palliative pathway will provide the best outcome. While multiple post-natal echocardiographic measures have been used to quantify degree of balance and predict success of either a 2V vs 1V surgical strategy, there is little data examining use of these indices prenatally. This study evaluates the hypothesis that similar measures on fetal echocardiography are predictive of 2V repair at initial operation for patients prenatally diagnosed with AVCDs. **Methods:** We conducted a retrospective, single center cohort study of patients with a prenatal diagnosis of AVCD and post-natal evaluation at our center between March 2013 and November 2017. We analyzed multiple 2D and color flow Doppler indices describing relative LV/RV inflow size, relative LV/RV ventricular size, RV/LV inflow angle, and ventricular septal defect size. Univariate and bivariate analyses were conducted to determine association and odds of 2V repair vs. a palliative procedure as initial surgical intervention. **Results:** 45 subjects were analyzed; 31 (69%) underwent an initial 2V repair at a median of 138 days, while 14 (31%) underwent palliative surgery (Table). Additional cardiac defects were uncommon in the 2V repair (22%) but universal in the palliative repair group. RV/LV inflow angle was significantly larger in 2V vs. palliated surgical groups (p=0.003)(Table). On bivariate analysis, larger RV/LV inflow angle (OR=2.07, 95% CI 1.28 - 3.37, p=0.003) and smaller VSD size (OR=1.35, 95% CI 1.00-1.81, p=0.05) was associated with 2V repair. In a subanalysis (n=31) eliminating LV dominant cases, larger inflow angle and smaller VSD was also predictive of 2V initial repair. Relative LV/RV inflow indices and ventricular dimensions were not predictive of 2V vs 1V repair in either primary or subanalysis. **Conclusion:** The RV/LV inflow angle and VSD size measured on fetal echocardiogram may be useful in predicting 2V repair at initial intervention and in counseling families with regard to postnatal prognosis in fetal AVCD.

Table. Fetal Echocardiographic Indices Predictive of Initial Biventricular Repair

	All Fetal AVCDs			Fetal AVCDs excluding LV Dominant AVCDs††		
	Initial Biventricular Repair (n=31, 68.9%)	Initial Palliative Intervention† (n=14, 31.1%)	p-value	Initial Biventricular Repair (n=21, 67.7%)	Initial Palliative Intervention† (n=10, 32.3%)	p-value
Clinical Characteristic						
GA at Fetal Scan*	26.6 (24.2 – 29.6)	28.8 (26.0 – 30.1)	0.356	26.0 (23.5 – 29.2)	29.3 (27.1 – 30.1)	0.03
GA at Birth (weeks)	37 (35 – 38)	38 (37 – 39)	0.189	37 (37 – 38)	38 (37 – 38)	0.605
Birthweight (g)	2.89 (2.44 – 3.30)	3.04 (2.55 – 3.40)	0.67	2.89 (2.50 – 3.30)	2.9 (2.41 – 3.40)	0.95
Age at Initial Surgery (days)	138 (114 – 189)	9 (6 – 58)	<0.001	136 (114 – 189)	6 (5 – 58)	0.003
Additional Cardiac Abnormality	7 (22.6)	14 (100.0)	<0.001	5 (23.8)	10 (100.0)	<0.001
Fetal Echocardiographic Indices						
RV/LV inflow angle	90.5 (7.5 – 97.0)	70.1 (44.8 – 81.6)	0.003	92.3 (81.6 – 96.6)	64.7 (44.8 – 73.5)	0.016
LAVV/RAVV annulus ratio	0.92 (0.77 – 1.20)	0.88 (0.40 – 1.18)	0.389	0.89 (0.55 – 0.92)	0.71 (0.38 – 0.92)	0.167
LV/RV length ratio	1.07 (1.04 – 1.20)	1.11 (1.00 – 1.19)	0.742	1.06 (1.04 – 1.14)	1.08 (0.83 – 1.19)	0.883
LV/RV width ratio	1.01 (0.90 – 1.26)	0.93 (0.71 – 1.13)	0.139	0.95 (0.90 – 1.09)	0.82 (0.69 – 0.99)	0.144
VSD size (mm)	5.9 (4.4 – 7.4)	8.2 (4.5 – 9.6)	0.091	5.6 (4.4 – 6.9)	9.3 (4.5 – 10.1)	0.064
Modified AVVI diameter**	0.48 (0.44 – 0.54)	0.47 (0.29 – 0.54)	0.389	0.47 (0.35 – 0.48)	0.42 (0.28 – 0.48)	0.167

Key
Continuous variables are reported as median (25th-75th range); Categorical variables are reported as frequency (percentage)
AVCD=atrioventricular canal defect; AVVI =atrioventricular valve index; GA=gestational age; LAVV=left atrioventricular valve; RAVV=right atrioventricular valve; VSD=ventricular septal defect
*Gestational Age at Fetal Scan=gestational age at prenatal scan used in study; patient may have had additional prenatal echocardiograms
**Modified AVVI (atrioventricular valve index) diameter=LV annulus diameter/ total AVV diameter in apical 4 chamber view
†Palliative intervention= all non-biventricular repair interventions; including but not limited to Norwood procedures, systemic to pulmonary artery shunts, pulmonary artery banding, bicaval anastomoses
††Fetal AVCDs excluding LV Dominant AVCDs=total study cohort minus patients with a LAVV/RAVV annulus ratio of ≥1.15

P1-36

Novel Associations Between Right Ventricular Function and Plasma Biomarkers of Myocardial Fibrosis in Infants with Tetralogy of Fallot

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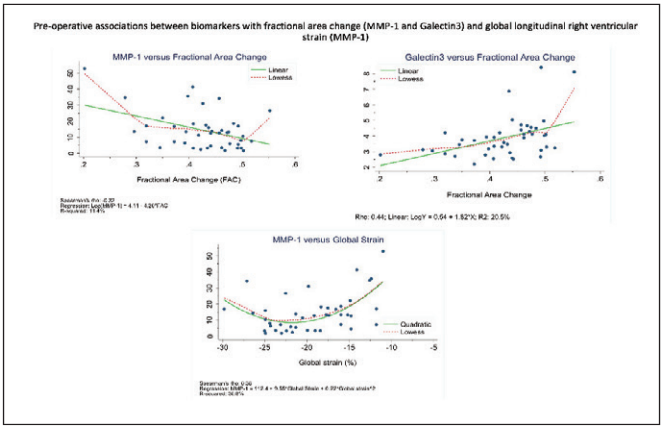
Background: After surgical repair for tetralogy of Fallot (TOF), myocardial fibrosis is associated with long term right ventricular (RV) dysfunction, however, little is known about pre-operative RV remodeling in these patients. The pre-operative associations of myocardial fibrosis and RV function have not been thoroughly studied. We sought to investigate the association of pre-operative levels of plasma biomarkers of myocardial fibrosis with right ventricular function in a population of infants undergoing initial TOF repair. **Methods:** We conducted a single-center prospective study of infants with TOF undergoing initial complete surgical repair. Biomarkers of fibrosis were measured from frozen plasma samples collected prior to cardiopulmonary bypass (MMP1, MMP9, ST2, Galectin3, PICP and PIIINP). RV function was assessed on pre-operative echocardiograms using fractional area change % (FAC) and global longitudinal RV strain (GLS). Associations between biomarkers and RV function were assessed using linear regression. **Results:** Forty-nine subjects had biomarker/echo pairs [32 (68%) male, 36 (77%)% white], median age at TOF repair 3.4 months (IQR: 2.52,5.2). Most had pulmonary valve stenosis (36, 77%). FAC was 43±7 % and RV GLS was -19.7±4.6%. Galectin3 had a moderate direct association with FAC, and MMP1 had a moderate inverse association with FAC and a non-linear association with RV GLS (Figures). **Conclusion:** Plasma biomarkers may add to the characterization of RV remodeling in TOF. These associations between plasma markers of fibrosis and imaging measures of RV remodeling, as well as their clinical significance need future study.



P1-37

Progressive Physiological and Anatomical Deterioration in Fetuses with Aortic Stenosis

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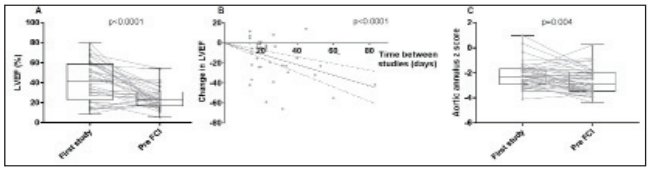
Background: Fetuses with mid-gestation aortic stenosis (AS) commonly evolve into hypoplastic left heart syndrome by birth. Fetal aortic valvuloplasty (FAV) is performed in an attempt to avert this progression. Data on the in utero natural history of fetuses with severe AS would be critical in determining candidacy for FAV. We investigated changes in physiological and anatomical parameters over time in fetuses with severe AS, prior to FAV. **Methods:** We included fetuses with severe AS who were referred for FAV and had at least 2 weeks between the initial and pre-FAV fetal echo (n=38), comparing anatomical and physiological echo parameters at the two time points. **Results:** The median time between studies was 21.5 days (range 14-83). Median gestational age at diagnosis was 21.6 weeks (range 18.6-27.4). The left ventricular ejection fraction (LVEF) decreased between the referral study and the pre-intervention study (median difference -12.65, p<0.0001), and the decrease in LVEF correlated with longer time between studies (figure A & B). Aortic valve annulus z score also decreased between the studies (figure C, median difference -0.54, p=0.005), as did the ascending aorta z score (p=0.013). LV sphericity (a marker of pathological remodeling) increased between the studies (P<0.0001). The proportion of fetuses with monophasic mitral inflow (indicating diastolic dysfunction) increased from 58.3 to 85.7% (p=0.013). The proportion with abnormal (bidirectional or left to right) foramen ovale (FO) flow increased from 76.5% to 100% (p=0.0012), while the presence of abnormal retrograde flow in the transverse aortic arch (TAA) increased from 71.4% to 100% (p=0.0001). Of the ten fetuses with normal antegrade flow in the TAA at the first

study, all had retrograde flow at the pre-intervention study, and no fetus changed from retrograde to antegrade (p=0.02). Similarly no fetus changed from abnormal to normal FO flow (p=0.04). **Conclusion:** Our findings show that severe AS is a progressive disease in the fetus, with both anatomical and physiological markers of deterioration over time. Further studies are warranted to elucidate the impact of disease progression on FAV outcomes, and to clarify whether earlier intervention would improve results.



P1-38

Natural History of Fetal Echocardiographic Findings Associated with Lower Urinary Tract Obstruction

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Background: Fetal lower urinary tract obstruction (LUTO) is associated with abnormal renal function and oligohydramnios. Although fetal echo findings associated with LUTO at a single time point have been described, the natural history of cardiac findings through postnatal life have not been reported. **Methods:** We included fetuses diagnosed with LUTO with ≥1 fetal echo performed between 1/2005-12/2017. Serial fetal and postnatal echos were reviewed, and indices of right ventricular (RV) and left ventricular (LV) hypertrophy and function, including tricuspid valve (TV) and mitral valve (MV) inflow times, were assessed. **Results:** 22 fetuses were identified; 1 was excluded due to hypoplastic left heart syndrome. Median gestational age at the first study was 26 (range: 17-32) weeks. 8/21 (38%) fetuses had cardiomegaly, 10/21 (48%) had RV hypertrophy, 7/21 (33%) had LV hypertrophy, and 9/21 (43%) had at least a small pericardial effusion. Median TV inflow time z-score was -0.6 (-2.6 to +1.4), and 4/21 (19%) had fused E/A waves consistent with diastolic dysfunction. Median MV inflow time z-score was -0.8 (-2.8 to +1.6). RV and LV systolic function were qualitatively decreased in 5/21 (24%) and 1/21 (5%), respectively. Among patients with serial fetal echos (n=5), median time between studies was 4 (2-6) weeks. RV hypertrophy increased in 3 of 5 patients, and LV hypertrophy in 2 of 5. Both RV and LV diastolic function worsened with TV inflow time z-score decreasing by 1.9 (0.5-2.0) and MV inflow time z-score by 0.9 (0.5-2.7). RV systolic function worsened in 2 of 5 patients; LV systolic function was unchanged. The pericardial effusions remained stable. Pregnancy outcomes included 15 live-births, 2 fetal demises, 1 termination, and 3 lost to follow-up. Among patients with serial postnatal echos (n=5), systolic function normalized by 3-10 days and ventricular hypertrophy by 20 days to 4 months. Of note, 4 (19%) had mildly hypoplastic left heart structures: 2 with arch hypoplasia and 2 with mitral and aortic stenosis. **Conclusion:** Fetuses with LUTO commonly present with cardiomegaly, ventricular hypertrophy, and pericardial effusion, perhaps due to abnormal renal function and release of vasoactive mediators. Ventricular hypertrophy and function, particularly of the RV, worsened over the course of gestation in this small series with postnatal normalization by several months of age. Interestingly, we found a high incidence of mild left heart hypoplasia, which has not previously been reported, and may be due to redistribution of cardiac output in fetuses with LUTO. Our findings require further investigation in larger series.

P1-39

Abnormal Right Ventricular-Pulmonary Vascular Coupling Persists in Preterm Infants

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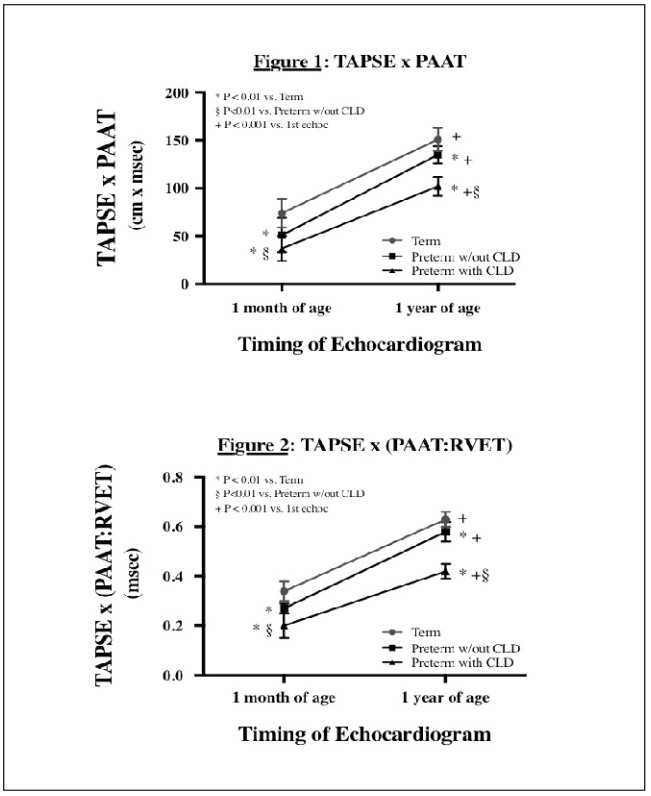
Background: Prematurity exposes the right ventricular-pulmonary vascular (RV-PV) axis to postnatal cardiovascular stress before myocardial development is completed. Although chronic lung disease (CLD) of prematurity can exert additional load to RV, its long-term consequences on RV-PV coupling are not precisely known. RV-PV coupling is characterized by the RV length-force relationship (tricuspid annular plane systolic excursion [TAPSE] vs. generated pulmonary artery systolic pressure [PASP]). Pulmonary artery acceleration time [PAAT] provides a validated estimate of PASP in infants. We hypothesized that the length-force relationship (TAPSE x PAAT), a non-invasive index of RV-PV coupling, is diminished in preterm infants compared to term infants. **Methods:** The study was conducted in a prospective cohort of 80 extreme preterm infants (< 29 weeks gestation and < 1500 grams at birth) enrolled through the Prematurity and Respiratory Outcomes Program. CLD, defined as the need for any respiratory support at 36 weeks post-menstrual age, was diagnosed in 48 preterm infants (60%). TAPSE (cm) for RV length shortening and PAAT (msec) for estimation of PASP were measured. PAAT was adjusted for RV ejection time to correct for heart rate. Comparisons of RV-PV coupling (TAPSE x PAAT) were made between the preterm cohort and 50 age- and weight- matched term-born healthy infants at one month and one year of age. **Results:** TAPSE x PAAT increased from one month to one year of age in both preterm- and term-born infant, but was significantly lower in all preterm infants at each time point, (Figure 1). Preterm-born infants with CLD had lower TAPSE x PAAT than those without CLD at both time points. None of the infants required respiratory support at one year of age. The same patterns were significant for TAPSE x (PAAT:RV ejection time), (Figure 2). Data analysis included adjustment for gestational age, body surface area and heart rate at each time point. **Conclusions:** Preterm infants show reduced RV-PV coupling at one month of age that persists to one year of age. This altered RV length-force relationship may be a distinct pathology of prematurity that is present even after resolution of CLD.



P1-40

Speckle-tracking Strain Calculation Packages in Children: A Head-to-Head Comparison of TomTec and QLAB

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Background: Strain may be calculated using a variety of software analysis tools. We aimed to compare values between the strain calculation packages available for the Philips Epiq platform, using three diverse pediatric cohorts and a variety of analysis settings. **Methods:** All patients were ≤18 years old with a biventricular circulation and a systemic left ventricle. Three groups were analyzed: (1) normal heart structure and function; (2) ventricular paced rhythm with QRS ≥120 msec; (3) flattened ventricular septum due to right ventricular volume or pressure overload. Each set of images was analyzed using 6 scenarios: QLAB 10.5, QLAB 10.8 (using quantification smoothness settings = low, medium and high; these are known to have a large impact on segmental tracking), TomTec 2DCPA at full acquisition frame rate (TT-Full), and TT at 30 fps (TT-30). Strain analysis included apical 4-chamber (AP4) and short axis mid-papillary (SAX-M) views. A mixed effects linear regression model main effect was considered significant if the p value was <0.05; pairwise p values were not adjusted for multiple comparisons. **Results:** 108 patients were included (36 per group). The mean±SD AP4 and SAX-M strain values (%) were: -24±2 / -31±3 (normal group); -17±5 / -24±7 (paced); and -20±3 / -27±5 (flattened septum). When considering all patients together, the packages that produced the most vs. least negative values for AP4 strain (%) were: QLAB 10.5 vs. QLAB 10.8-med (-22 vs. -19; p<0.001); for SAX-M (%) these were TT-Full vs. QLAB 10.5 (-29 vs. -23; p<0.001). Differences between strain analyses by group are shown in the Figure. For QLAB 10.8, mean strain did not differ by quantification smoothness setting for any group. QLAB 10.5 differed from QLAB 10.8 and TT for all groups, for both SAX-M and AP4 strain. TT-30 differed from TT-Full only for the flattened septum group. QLAB 10.8 was similar

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to TT-Full for both strain components for all groups. **Conclusion:** When measuring global strain, QLAB 10.5 measurements consistently differ from the other options. QLAB 10.8 strain did not differ by choice of quantification smoothness and was equivalent to TT-Full, which differed from TT-30 fps only in patients with a flattened septum. Future studies are planned to investigate the differences between these tools for regional function and synchrony assessment.

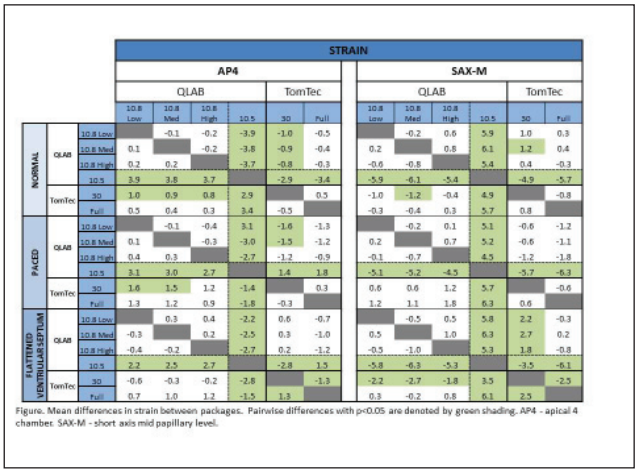

Figure. Mean differences in strain between packages. Pairwise differences with p<0.05 are denoted by green shading. AP4 - apical 4 chamber. SAX-M - short axis mid papillary level.

P1-41

The Effect of Digoxin on Cardiac Mechanics in the Interstage Period: Insights Using Non-Invasive Pressure-Volume Loop Analysis

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Background: Reports suggest that digoxin use in the interstage period confers a survival benefit in patients with single right ventricle physiology after the Norwood operation. The mechanisms behind this finding are unknown. The objective of this study was to determine if single right ventricle patients taking digoxin displayed more optimal cardiac mechanics than those who were not on digoxin. **Methods:** Core-lab echocardiogram measures and medication data in the interstage period were collected from the publically available Pediatric Heart Network Single Ventricle Reconstruction trial database at two time points: 1) prior to Norwood hospitalization discharge and 2) during the pre-operative evaluation prior to superior cavopulmonary connection (SCPC). End-systolic elastance (Ees), a measure of contractility, was calculated as (0.9 * SBP/end-systolic volume). Arterial elastance (Ea), a measure of afterload, was calculated as (0.9 * SBP/stroke volume). Ventriculo-arterial coupling was expressed as the ratio of Ea/Ees. **Results:** Differences between patients that were and were not taking digoxin are reported in the table. There were no differences in Ees, Ea, or Ea/Ees between the groups at either time-point. **Conclusion:** Single right ventricle patients taking digoxin did not display improved contractility, afterload, or ventriculo-arterial coupling compared to the non-digoxin group in the interstage period. Other mechanisms that explain their improved survival should be further explored.

Post-Norwood Discharge Study			
	Digoxin (n=155)	**Non-Digoxin (n=297)**	**p-value**
Age (days)	22.0 (16.0-31.0)	20.0 (14.0-28.0)	0.035
Height (cm)	50.0 (48.5-52.0)	50.0 (49.0-52.0)	0.956
Weight (kg)	3.31 ± 0.52	3.20 ± 0.56	0.048
SBP (mm Hg)	81.0 (73.0-87.0)	77.0 (70.0-84.0)	0.003
DBP (mm Hg)	42.0 (37.0-50.0)	43.0 (37.0-49.0)	0.832
RV EDV (mL)	14.2 (11.6-20.7)	13.9 (10.3-20.0)	0.267
RV EF (%)	45.1 (40.4-51.8)	45.8 (40.4-50.3)	0.987
Ees (mm Hg/mL/m^2)	10.2 (6.4-12.5)	9.0 (6.1-13.2)	0.978
Ea (mm Hg/mL/m^2)	8.9 (5.9-11.4)	8.8 (6.0-11.9)	0.794
Ea/Ees	0.9 (0.7-1.1)	0.9 (0.8-1.1)	0.987
Pre-SCPC Evaluation			
	Digoxin (n=98)	**Non-Digoxin (n=285)**	**p-value**
Age (days)	139.0 (120.0-172.0)	139.0 (117.0-170.0)	0.784
Height (cm)	61.0 (59.0-64.0)	61.0 (58.5-64.0)	0.536
Weight (kg)	5.8 (5.1-6.4)	5.7 (5.1-6.3)	0.746
SBP (mm Hg)	91.0 (82.0-98.0)	86.0 (78.0-95.0)	0.022
DBP (mm Hg)	44.0 (37.0-55.0)	43.0 (37.0-51.0)	0.383
RV EDV (mL)	26.3 (20.6-31.3)	24.9 (17.7-31.4)	0.173
RV EF (%)	42.8 ± 7.4	43.9 ± 8.1	0.273
Ees (mm Hg/mL/m^2)	5.5 (4.3-7.4)	5.7 (4.2-8.4)	0.492
Ea (mm Hg/mL/m^2)	5.7 (4.6-7.8)	5.7 (4.5-7.9)	0.939
Ea/Ees	1.03 (0.84-1.24)	1.00 (0.81-1.22)	0.400

Results reported as mean ± standard deviation or median (interquartile range). DBP = diastolic blood pressure; Ea = arterial elastance; EDV = end-diastolic volume; Ees = end-systolic elastance; EF = ejection fraction; RV = right ventricle; TV = tricuspid valve; SBP = systolic blood pressure; SCPC = superior cavopulmonary anastomosis

P1-42

Umbilical Venous Volume Flow is Decreased in the Fetus with Congenital Heart Disease

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Background: Placentas of fetuses with congenital heart disease (CHD) may be abnormal, due to shared signaling factors that alter both cardiovascular and placental development. A strong association exists between CHD and preeclampsia, a disorder of placental vascular function. We hypothesize that the placenta in the fetus with CHD has decreased blood flow relative to normal. **Methods:** Umbilical venous volume flow (UVVF) is a non-invasive method to quantify in-utero umbilical vein flow from the ultrasound-derived cross-sectional area and Doppler flow waveform velocity of the umbilical vein. We performed a retrospective cross-sectional study examining UVVF of fetuses at 20-25 weeks' gestation with tetralogy of Fallot, D-transposition of the great arteries or single ventricle CHD, compared to normally-developing fetuses or fetuses with isolated non-cardiac anomalies that did not impact growth or hemodynamics. All eligible studies between September 2016 and June 2017 were reviewed and subjects included if the appropriate images were available. **Results:** 31 cases (23 fetuses with single ventricles, 5 with tetralogy and 3 with transposition) and 144 controls were studied. Case and control groups have similar mean maternal age, gestational age, fetal weight and proportion of prenatal risk factors. The mean absolute UVVF, UVVF/gestational age and UVVF/fetal weight in CHD fetuses is significantly lower than controls (Table 1). Differences remain significant when examining only single ventricle fetuses compared to controls. Combined cardiac output (CCO) in cases and controls are the same, with trend towards a difference in ratio of absolute UVVF to CCO (p=0.07). **Conclusions:** There is a quantifiable decrease in placental blood flow in fetuses with CHD in comparison to normal, implying a relative decrease in nutrient-rich placental blood delivery to the developing fetus with CHD. Our findings demonstrate the potential of UVVF as a non-invasive measure of placental abnormality in utero. Characterizing the degree of diminution in UVVF related to specific cardiovascular conditions, correlating UVVF with placental pathology, as well as exploring the association with postnatal outcomes are next steps worthy of investigation.

Table 1. Baseline characteristics and UVVF findings in fetuses with and without CHD.

	Control Fetuses (n=144)	Fetuses with CHD (n=31)	p-value
Maternal Age (years)	30.9 (5.1)	31.2 (5.6)	0.75
Gestational Age (weeks)	22.1 (1.3)	22.2 (1.4)	0.92
Fetal Weight (g)	525.1 (118.5)	511.7 (116.4)	0.57
Presence of Maternal Risk Factors	53 (36.8%)	6 (19.4%)	0.06
CCO (mL/min/kg)	463.6 (133.7)	465.4 (197.6)	0.96
Absolute UVVF (mL/min)	62.3 (21.8)	51.5 (18.7)	0.01
UVVF/gestational age (mL/min/wk)	2.8 (0.9)	2.3 (0.7)	0.004
UVVF/fetal weight (mL/min/kg)	0.12 (0.03)	0.10 (0.02)	0.001

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Mitral Valve Apparatus in Children with Hypertrophic Cardiomyopathy: Unique Insights from Three-Dimensional Echocardiography

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Introduction: Abnormalities of the mitral valve (MV) apparatus have been studied infrequently in children with HCM. Our objective was to outline abnormalities of the MV apparatus in children with HCM using three-dimensional echocardiography (3DE). **Methods:** We studied 32 HCM and 32 age-matched controls (C), using Tomtec 3D MV analysis software. Static measurements of MV annulus and leaflets were made in mid-systole, while dynamic measurements were made throughout systole. Measurements were adjusted by body surface area (BSA) and Wilcoxon test was used for comparing between HCM and C patients. Potential cut off values for annular and leaflet measurements as determinants of mitral regurgitation (MR) and systolic anterior motion (SAM) were calculated using ROC (AUC: area under the curve, SE: sensitivity, SP: specificity). **Results:** Static analysis of the annulus showed that the anteroposterior (AP) and anterolateral-posteromedial (AL-PM) diameters and annular circumference and area were significantly larger in the HCM group (Table 1). Static measurements of the leaflets showed that tenting height and area were increased in HCM, however, tenting volume did not increase significantly. The area and length of the posterior MV leaflet were increased, however, no difference was found in the anterior leaflet dimensions. This may be due to the fact that a portion of anterior leaflet remains below the coaptation point in systole and thus, remains unmeasured by 3DE (Fig 1). In the dynamic assessment, the maximum annular displacement was reduced in the HCM group during systole. A tenting height cut off value of 5.60 (cm/m) (AUC: 0.74, SE: 74%, SP: 89%), and a posterior leaflet length cut off value of 0.96 (cm/m) (AUC: 0.80, SE: 78%, SP: 67%) were associated with MR. Increase in the tenting height was also associated with SAM, with a cut off value of 6.10 (cm/m) (AUC: 0.79, SE: 71% SP: 94%). **Conclusions:** Children with HCM manifest various MV apparatus abnormalities detected by 3DE. Most abnormalities were related to the anterior movement of the coaptation point of the leaflets and an increase in the tenting height. A larger cohort of patients enrolled via multicenter studies may offer a better understanding of the role of the MV abnormalities in mitral regurgitation and LV outflow tract obstruction in children with HCM.

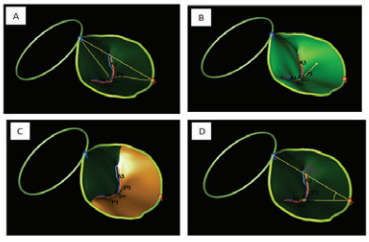
Table 1. Demographics and 3DE measurements among the study population

	Controls (n=32)	HCM (n=32)	p value
Demographic characteristics			
Female	8 (25.00%)	4 (12.50%)	0.337
Age (years)	13.91 (7.96 -17.67)	14.12 (8.17 - 17.87)	0.9572
LVSd (z score)	-1.1 (-1.35 - -0.31)	5.01 (2.56 - 10.40)*	<0.001
LVPWd (z score)	-0.84 (-1.23 - 0.11)	2.67 (1.41 - 4.33)*	<0.001
Annulus			
AP Diameter/VBSA (cm/m)	2.05 (1.92 - 2.27)	2.30 (2.13 - 2.64)*	0.0026
AL-PM Diameter/VBSA (cm/m)	2.29 (2.12 - 2.55)	2.53 (2.30 - 2.72)*	0.0184
Annulus Circumference/VBSA (cm/m)	7.13 (6.55 - 7.86)	8.03 (7.28 - 8.84)*	0.007
Annulus Area/BSA (cm^2/m^2)	3.82 (3.24 - 4.61)	4.81 (3.89 - 5.78)*	0.0088
Leaflets			
Tenting Volume/BSA (cm^3/m^2)	0.78 (0.59 - 1.01)	0.93 (0.67 - 1.42)	0.0833
Tenting Area/BSA (cm^2/m^2)	0.59 (0.49 - 0.75)	0.67 (0.61 - 0.97)*	0.0454
Tenting Height/VBSA (cm/m)	4.56 (4.02 - 5.27)	5.93 (4.91 - 7.64)*	0.0013
Anterior Leaflet Area/BSA (cm^2/m^2)	2.54 (2.14 - 3.32)	2.61 (2.25 - 3.26)	0.9679
Posterior Leaflet Area/BSA (cm^2/m^2)	1.72 (1.57 – 1.87)	2.78 (2.22 – 3.41)*	<0.001
Anterior Leaflet Length/VBSA (cm/m)	1.68 (1.49 - 1.89)	1.57 (1.48 - 1.78)	0.3902
Posterior Leaflet Length/VBSA (cm/m)	0.70 (0.60 - 0.76)	1.13 (0.86 - 1.27)*	<0.001
Posterior Leaflet Angle (°)	44.93 (35.94 - 52.02)	36.66 (29.31 - 40.69)*	0.0028
Dynamic			
Annular Displacement/VBSA (mm/m^2)	9.27 (7.74 - 10.53)	8.16 (6.49 - 9.68)*	0.0157

BSA: Body Surface Area, LVSd: LV septal thickness in diastole, LVPWd: LV posterior wall thickness in diastole, 3DE Measurements, presented as median (interquartile range), *p<0.05

Figure 1: Changes in MV anatomy detected by 3DE in HCM (dashed lines) vs controls (solid lines)

Figure 2: 3DE representations of the principal parameters found in HCM patients



A: Tenting Area (cm2), B: Tenting Height (cm), C: Posterior Leaflet Area (cm2), D: Posterior Leaflet Angle (°). (TomTec Imaging System, Munich, Germany).

P1-44

Left Ventricular Dysfunction is Associated with Fetal Demise in Tricuspid Valve Dysplasia

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Introduction: Ebstein's anomaly and tricuspid valve dysplasia (EA/TVD) are associated with high risk of intrauterine fetal demise (IUFD). The reason for this finding is incompletely understood, with right ventricular (RV) and pulmonary valve flow predominantly identified in prior studies. We hypothesised that abnormal left ventricular (LV) function is also important due to ventricular interactions and dyssynchrony. **Methods:** The final fetal echocardiogram in cases of EA/TVD resulting in intrauterine fetal demise was identified and gestation-matched to survivors to one year of age (S). Echocardiograms were analysed for systemic (uterine artery pulsatility index - UA PI, cardiothoracic area ratio) and RV parameters (celemajer index) as well as LV systolic dysfunction (LV ejection fraction), dyssynchrony (Standard Deviation of 6-segment four chamber time to peak (T2PSD) and a novel dyssynchrony index ((DI = average peak segmental value - average global value)/average peak segmental value) and filling abnormalities (mitral valve inflow time and velocity, systolic to diastolic time (SD ratio). Fisher's exact test and unpaired T-tests were performed. **Results:** There were 27 cases (S-17, IUFD-10) identified, average gestation at analysis 27 weeks (range 20-34weeks). TV displacement, Celemajer index, CTAR and hydrops were not different between groups. Pulmonary regurgitation was more prevalent in IUFD (7/10, 70%) vs S (2/15, 13%) (p=0.009). Retrograde ductal flow was more common in IUFD with borderline significance (IUFD 8/10 - 80%; S 7/17 - 41%, p=0.107). LV ejection fraction was reduced in IUFD (LVEF<45% IUFD 4/9 44%, S 0/9 (0%), p=0.041). Radial T2PSD and DI were higher in the IUFD group, but this did not reach significance. Mitral e-wave velocity (S 0.31±.08, IUFD 0.45±0.04, p=0.005) and SD ratio (S 1.33±0.24, IUFD 1.82±0.44, p=0.02) were increased in IUFD, whereas percentage inflow time (S 43±5%, IUFD 37±8%, p=0.038) was decreased. The UA PI z-score was increased in IUFD (S 1.2±1.5, IUFD 3.8±2.3, p=0.005). **Conclusion:** Left ventricular systolic and filling abnormalities are more prevalent in IUFD than surviving cases of fetal EA/TVD. Abnormal UA PI may be an important easily assessed surrogate marker of high risk which is affected by pulmonary regurgitation and left ventricular output. A large multicentre study assessment of these measures is warranted.

P1-45

Kawasaki Disease: Changes in Diagnosis Based on 2017 Echocardiogram Criteria

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Kawasaki disease (KD) is a common cause of coronary vasculitis in children less than 5 years of age. Complete KD is diagnosed based on fever ≥5 days with principal clinical features. When not all clinical features are present, echocardiography (echo) findings can impact the diagnosis of incomplete KD. The American Heart Association (AHA) in 2004 published guidelines for positive echo findings. The AHA revised the diagnostic criteria in 2017. Our aim was to evaluate the effect on diagnostic outcomes using the revised 2017 criteria, on previously treated KD patients.

This was a retrospective chart review of patients diagnosed with KD during the year 2016 at our institution. Clinical features, supplemental lab values, and echo results were reviewed. Echo findings were classified as positive or negative based on AHA 2004 and 2017 guidelines and results were compared. 29 patients were diagnosed with KD, and treated with intravenous immunoglobulin (IVIG). One patient was excluded as the initial echo was unavailable. 10 out of 28 patients met clinical criteria for complete KD and 18 had incomplete KD. 13/28 (46%) patients had positive echo findings based on 2004 criteria. In 5 out of these 13, the echo did not meet the 2017 criteria. All differences were due to periarterial brightness and lack of tapering in the coronary arteries, which were diagnostic criteria in 2004 but eliminated in 2017. Three of these patients had complete KD based on clinical features and would have been treated irrespective of echocardiogram findings. Two patients had incomplete KD and were treated in consideration of a positive echo. Overall, almost half of all patients were noted to have periarterial brightness (13/28, 46%) and lack of tapering (16/28, 57%) on echo. A z-score ≥2.5 in the right coronary artery and left anterior descending arteries was noted in 6 (21%) and 3 (4%) patients respectively, similar to previously published data. Two of the incomplete KD patients did not meet the 2004 or 2017 echo criteria, but had a left main coronary artery (LMCA) z-score ≥ 2.5, and were treated based on clinical suspicion. Per guidelines, LMCA z-scores should be used with caution due to anatomic variations. The AHA recently issued updated guidelines in 2017 for specific echo findings that are considered to be positive for KD. Based on re-assessment of patients diagnosed in 2016, 7% (2/28) would not have fulfilled revised AHA 2017 echo criteria and may not have received IVIG treatment. Removal of periarterial brightness and lack of tapering from the 2017 echo criteria may result in fewer KD diagnoses in the future.

Poster Session 1 (P1)

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P1-46

Association of Left-Sided Mural Leaflet Morphology with Surgical Approach and Postoperative Left Atrioventricular Valve Regurgitation in Atrioventricular Canal Defect

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Background: Atrioventricular canal defect (AVC) has an abnormal common valve with superior and inferior bridging leaflets that span across both ventricles. A "mural" leaflet completes the trifoliate arrangement of the left-sided valve. Left atrioventricular valve regurgitation (LAVVR) following repair is a significant source of morbidity, often requiring reintervention. Regurgitation often arises from the region of coaptation between bridging leaflets, termed the "cleft". We hypothesized that a smaller mural leaflet and longer cleft in the left atrioventricular valve (LAVV) would be associated with ventricular unbalance and increased severity of postoperative LAVVR. **Methods:** We developed three preoperative echocardiographic measures of left-sided mural leaflet morphology: the angle of the leaflet tip, the length of the cleft as a proportion of the LV diameter, and the area of the mural leaflet as a proportion of the LAVV area. We reviewed all 165 patients with complete or transitional AVC who underwent biventricular repair between 1/1/11 and 12/31/16, of which 156 had sufficient imaging for measurements. **Results:** More acute mural leaflet tip angle and smaller mural leaflet area were significantly associated with unbalance to the right ventricle (p= 0.03; p=0.0008). However, smaller mural leaflet area was not associated with postoperative LAVVR. Shorter cleft lengths were associated with transitional AVC (p=0.01). Larger mural leaflet area was associated with repeat bypass runs during initial surgery (p=0.008). There was a trend towards significant association between smaller mural leaflet and partial or no cleft closure during AVC repair (p=0.052). **Conclusion:** Few studies have examined characteristics of the left-sided mural leaflet in AVC or its association with outcome. Unbalanced AVC with a dominant right ventricle was more likely to have a small mural leaflet. Surgeons may be reluctant to close the cleft in those with smaller mural leaflets however it does not appear to impact postoperative LAVVR. Larger mural leaflets may increase surgical complexity and lead to repeat bypass runs. Further study of the left-sided mural leaflet may improve our understanding of the morphologic complexities in AVC.

P1-47

Reducing Transthoracic Echocardiogram Diagnostic Error in Congenital Heart Disease: A Quality Improvement Project

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Background: Diagnostic errors (DE) by transthoracic echocardiography (TTE), although infrequent, can adversely affect patient outcome, and may be preventable. At our institution we began a weekly imaging review conference (IRC), wherein all surgical cases were reviewed by a group of two to six advanced imaging cardiologists in an attempt to reduce DE. The primary aim of this study was to compare the incidence and severity of DE by TTE pre and post implementation of IRC. **Methods:** A retrospective chart review of all patients (age 1 day- 18 years) with congenital heart disease requiring surgery at Children's Mercy Hospital between December 01, 2013 and December 01, 2016 was performed. In June 2015, the weekly IRC was implemented. Cases prior to June 2015 composed our pre IRC cohort and those following our post IRC cohort. Patients who had TTE less than six months prior to surgical intervention were included and the findings on TTE were compared to that found during surgery. Data collected included patient demographics, location and time of study, sedation, and sonographer/interpreter experience. Cases in which there was a discrepancy between the TTE report and surgical report were labeled DE and further reviewed to categorize the discrepancy. Characterization of the DE included: preventability, severity (i.e. minor, moderate, severe), and contributors to error. The pre IRC and post IRC cohorts were compared using chi-square or Fisher's exact tests. Logistic regression analysis was used to determine possible predictors of DE. **Results:** A total of 834 cases were reviewed (402 pre IRC, 432 post IRC). Overall DE rate was 14.5% pre IRC (n=59; 44 minor, 12 moderate, 3 major) vs 9.6% post IRC [(n=43; 40 minor, 2 moderate, 1 major), p<0.05]. The IRC prevented DE in 14 cases (9 minor, 5 moderate). Incidence of moderate and major DE decreased from 3.7% to 0.7%. For the post IRC cohort, fewer DE were attributed to image interpretation (n=13 vs 20; p<0.05), incomplete examination (n=3 vs 27; p<0.01) and uncooperative patient (n=1 vs 16; p<0.01). There was no difference in interpreter experience (p=0.29) while sonographer experience in pre IRC cohort was lower (>5 years experience 34% vs 49%; p<0.05). Logistic regression revealed that the odds of DE in pre IRC cohort was 1.74 (95% CI: (1.13, 2.69); p-value=0.01) times that of the post IRC cohort. **Conclusion:** A focused imaging review conference by pediatric cardiologists specializing in advanced cardiac imaging reduced DE by TTE in patients undergoing congenital heart surgery. Large, multi-center studies could reveal whether our findings can be generalized across sites.

P1-48

Prenatal Detection, Comorbidities and Management of Vascular Rings: A 15-Year Regional Study

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Background: Vascular rings (VR) are rare and traditionally present with symptoms, making the need for division clear. The three vessel and trachea view is now widely used in obstetrical screening and may enhance prenatal detection. There is little published data on large series of VR in the modern era. We sought to examine trends in prenatal detection, associated anomalies and clinical outcomes of pediatric patients with VR. **Methods:** We retrospectively reviewed all pediatric patients between 2003-2017 in our regional center with VR. **Results:** Of 96 patients with VR, 23 (24%) had a prenatal diagnosis with no prenatal diagnoses prior to 2010. Prenatal detection rates increased over time (Table 1). Most VR diagnoses were right aortic arch/aberrant left subclavian artery/left ductus (73%, 70/96). The remainder, aside from one, had double aortic arch (DAA) (26%, 25/96). DAA was significantly less likely to be diagnosed prenatally than right aortic arch/aberrant left subclavian/left ductus (8% (2/25) vs 30% (21/70), p 0.03). Prenatally diagnosed VR were significantly more likely to have additional cardiac lesions (74% (17/23) vs 47% (34/73) postnatal, p 0.02). There was no difference in the rate of associated genetic abnormalities between groups (30% (7/23) prenatal vs 19% (14/73) postnatal, p 0.25). Need for surgical intervention was common and comparable between pre and postnatal groups (91% (21/23) prenatal vs 84% (61/73) postnatal, p 0.36). Of those with isolated VR, there was no difference in need for surgery (67% (4/6) prenatal vs 88% (64/73) postnatal, p 0.15). Those with prenatal diagnoses were less likely to have additional imaging (CT or MRI) compared with those diagnosed postnatally (12% (5/23) prenatal vs 59% (43/73) postnatal, p 0.002). Additional imaging changed the echo diagnosis of VR type in one patient. **Conclusion:** This study reports the largest contemporary cohort of VR. Prenatal detection of VR has improved substantially but there is room for improvement, especially for DAA. Surprisingly the diagnosis of a VR has the same rate of surgery regardless of pre/postnatal detection, even in isolation. The rate of genetic abnormalities is higher than previously reported, suggesting the need for genetic counseling. The reliability of echo diagnosis in both groups questions the need for further imaging modalities.

Table 1. Prenatally diagnosed vascular rings from 2003-2017.

Year of prenatal screening	Total number	Number with a prenatal diagnosis
2003-2009	38	0 (0%)
2010-2012	24	5 (17%)
2013-2015	26	13 (50%)
2016-2017	8	5 (62%)

P1-49

Increased Preload and Afterload Stressors during the First Interstage May Unmask Impaired Right Ventricular Contractile Reserve in Hypoplastic Left Heart Syndrome (HLHS): A Longitudinal Speckle Tracking Echocardiography Study

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Background: Speckle tracking echocardiography (STE) strain (S) provides a reproducible non-geometric measure of right ventricle (RV) contraction while strain rate (SR) is a validated measure of RV contractility in HLHS but "normal" reference values do not exist. We longitudinally followed a cohort of HLHS patients and report STE parameters derived from the surviving cohort to provide as a reference and explore differences with non-survivors. **Methods:** Prospectively recruited HLHS patients underwent a functional echocardiogram prior to staged palliation (Norwood-Sano, Glenn and Fontan) and post-Fontan. STE analysis for global longitudinal and basal circumferential S and SR were performed (GE, EchoPAC). Using a survivor cohort, we generated normal ranges for those STE variables. Comparison was made for those variables in a cohort who either died or underwent heart transplantation (HTx) using the Mann Whitney U test. Data is presented as median [IQR]. **Results:** Of 55 patients, 18 died or underwent HTx at a median follow-up of 8.1 years [5.8 - 9.0]. Survivors underwent Norwood at 8 days [6 - 14], Glenn at 5.7 months [4.8 - 6.0], and Fontan at 3.3 years [2.9 - 3.8]. In the death/HTx cohort, STE data was available in 16 pre-Norwood, 15 pre-Glenn, 4 pre-Fontan and 2 post-Fontan. Reference longitudinal and circumferential S and SR values were derived from survivors (Table). Due to low number of death/HTx STE data available at pre and post-Fontan stages, comparison was only made between cohorts for pre-Norwood and pre-Glenn. The death/HTx cohort had lower longitudinal SR (-0.8 [-1.0, -0.7] vs -1.1 [-1.2, -0.9] 1/s, p=0.02) and circumferential SR (-0.7 [-0.9, -0.6] vs -1.0 [-1.2, -0.8] 1/s, p=0.01) at the pre-Glenn stage. No difference was found in longitudinal or circumferential strain. **Conclusion:** We report normative data for RV STE longitudinal and circumferential S and SR in HLHS survivors to serve as reference values. HLHS children who died or underwent HTx had lower longitudinal and circumferential SR in the first interstage. The increased RV preload and afterload stressors at pre-Glenn may "unmask" and represent a unique opportunity to assess for impaired RV contractile reserve in HLHS. STE SR

appears more sensitive than S for early detection of RV dysfunction in HLHS and should be included in future studies.

Table: Median, 25th, and 75th percentile values of longitudinal and circumferential strain and strain rate for a surviving cohort of 37 children with HLHS

	Pre-Norwood	Pre-Glenn	Pre-Fontan	Post-Fontan
Longitudinal strain (%)	-18.8 [-20.8, -16.4]	-16.8 [-18.8, -14.5]	-17.9 [-19.4, -15.0]	-16.5 [-18.6, -12.9]
Longitudinal strain rate (1/s)	-1.6 [-1.8, -1.4]	-1.1 [-1.2, -0.9]	-0.9 [-1.1, -0.8]	-1.0 [-1.2, -0.9]
Circumferential strain (%)	-10.3 [-13.0, -8.3]	-12.5 [-15.6, -10.1]	-11.9 [-14.0, -9.3]	-12.1 [-15.6, -8.2]
Circumferential strain rate (1/s)	-1.3 [-1.4, -1.1]	-1.0 [-1.2, -0.8]	-0.8 [-1.1, -0.7]	-1.0 [-1.2, -0.8]
RV Fractional Area Change (%)	43.8 [41.1 – 49.3]	43.0 [39.1 – 45.7]	40.1 [38.3 – 46.0]	39.8 [35.0 – 43.2]

P1-50

Do Giant Coronary Aneurysms Due to Kawasaki Disease Affect Long Term Ventricular Function?

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Background: Few studies have examined long term left ventricular (LV) function in patients with Kawasaki Disease (KD) with aneurysms. We aim to determine if functional differences exist between patients with giant aneurysms, small aneurysms and no aneurysms. **Methods:** 184 patients with KD diagnosed from 2005-2015 were analyzed. There were 68 patients (37%) in the no aneurysm (NA) group, 57 patients (31%) in the small aneurysm (SMA) group and 59 patients (32%) in the giant aneurysm (GAA) group. Small aneurysm was defined as a coronary artery z score of ≥2.5 to <5. A giant aneurysm was defined as a z score of ≥10 or an absolute dimension of ≥8mm. An echo at last follow up was analyzed. **Results:** Median follow up duration was 7.6 years (range 4.0 - 11.3 years) for the GAA group, 2.1 years (1.2 - 5.9 years) for the SMA group and 1.2 years (0.1 - 1.5 years) for the NA group. There was no difference in long term left ventricular end diastolic dimension z-score or ejection fraction between the groups. There was a significant difference in mean longitudinal strain rate [GAA (-1.16 ± 0.28), SMA (-1.25 ± 0.31), NA (-1.30 ± 0.32), p=0.04] across the groups. No difference was observed between the groups in mean circumferential strain, mean longitudinal strain or mean circumferential strain rate. A significant difference was observed in isovolumic relaxation time [GAA (61.3 ± 10.2), SMA (58.5 ± 8.8), NA (57.3 ± 7.6), p=0.04], isovolumic contraction time [GAA (68.0 ± 8.6), SMA (63.3 ± 8.4), NA (61.8 ± 8.3), p<0.01] and statistical but likely not clinical difference in mitral valve E/A velocity ratio [GAA (2.0 ± 0.4), SMA (1.8 ± 0.3), NA (1.9 ± 0.4), p=0.01]. **Conclusion:** Long term follow up of KD patients with GAA and SMA shows impaired systolic and diastolic myocardial function. The clinical significance of these findings warrants further investigation.

P1-51

Factors Associated With Early Left Ventricular Dysfunction Following Repair of Ventricular Septal Defects

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Background: Echocardiographic assessment of left ventricular (LV) function can be challenging in the setting of a hemodynamically significant ventricular septal defect (VSD), since increased preload can mask underlying LV dysfunction. Strain measures have been shown to detect preoperative dysfunction in other volume loading lesions such as mitral and aortic regurgitation. The purpose of this study is to 1) characterize LV performance before and after VSD repair, and 2) elucidate variables associated with early postoperative LV dysfunction. **Methods:** Sixty consecutive children with repair of an isolated, hemodynamically significant VSD were included. Demographic, clinical, and surgical data were retrospectively collected. Pre and postoperative echocardiographic images were reviewed, and indicators of LV function were measured by the primary investigator. Postoperative LV dysfunction was defined as an ejection fraction (EF) < 50% using the 5/6 area x length method. **Results:** Preoperative LV EF (66.3% +/- 4.2 vs. 53.8% +/- 8.2), LV end-diastolic volume (25.0 mL +/- 13.1 vs. 17.8 mL +/- 9.9), and LV fractional shortening (39.3% +/- 5.1 vs. 28.6% +/- 7.1) were significantly greater than postoperative values (all p<0.0001). All subjects had a normal preoperative LV EF, and 21 (35%) subjects developed postoperative LV dysfunction. By univariate analysis, preoperative global longitudinal strain (GLS) (p=0.0002), global radial strain (p=0.004), and LV end-diastolic dimension z-score (LVEDDz) (p=0.02) were significantly different between subjects with and without postoperative LV dysfunction (Table 1). In a multivariate model, GLS (OR 0.76, 95% CI 0.58-0.99, p=0.04) and LVEDDz (OR 0.57, 95% CI 0.33-0.97, p=0.04) remained significantly different. Using receiver operating characteristic curves, GLS magnitude < -16.7% (AUC 0.81, p<0.0001) and LVEDDz > 2.66 (AUC 0.66, p=0.02) were associated with postoperative dysfunction. **Conclusion:** LV dysfunction is common immediately following repair of hemodynamically significant VSDs, with LV EF, LV fractional shortening, and LV end-diastolic volume decreasing significantly. Lower preoperative GLS magnitude and greater preoperative LVEDDz are independently associated with postoperative LV dysfunction, and may guide timing and expectations of VSD repair.

Table 1: Univariate analysis of preoperative and surgical variables

	Postop EF > 50% (n=39)	Postop EF < 50% (n=21)	P-value
Age (days)	234 (77-256)	161 (99-211)	0.94
Weight (kg)	6.3 +/- 3.8	5.3 +/- 1.3	0.27
BSA (m^2)	0.3 +/- 0.1	0.3 +/- 0.1	0.31
Cardiopulmonary bypass time (minutes)	83.4 +/- 25.6	87.7 +/- 22.8	0.52
Crossclamp time (minutes)	51.5 +/- 17.1	56.1 +/- 14.7	0.30
Longest VSD diameter (mm)	7.1 +/- 2.1	7.0 +/- 1.4	0.75
VSD area (cm^2) indexed to BSA (m^2)	1.6 +/- 0.9	1.7 +/- 0.7	0.81
VSD area (cm^2) indexed to Ao annulus length (cm)	0.7 +/- 0.2	0.7 +/- 0.2	0.98
LV end-diastolic volume (mL) indexed to BSA (m^2)	72.6 +/- 25.6	82.1 +/- 16.7	0.09
EF (%)	67.0 +/- 3.8	65.0 +/- 4.6	0.07
LV end-diastolic dimension z-score	2.1 +/- 2.3	3.3 +/- 1.6	**0.02**
Shortening fraction (%)	39.8 +/- 5.1	38.4 +/- 5.1	0.29
LV outflow tract VTI (cm)	1.3 +/- 0.4	1.3 +/- 0.4	0.78
VCFc (circ/s)	1.1 +/- 0.3	1.1 +/- 0.2	0.18
Global Longitudinal Strain (%)	-19.4 +/- 3.7	-15.2 +/- 3.9	**0.0002**
Global Radial Strain (%)	39.9 +/- 19.1	23.8 +/- 13.0	**0.004**
Global Circumferential Strain (%)	-23.8 +/- 4.9	-21.6 +/- 5.2	0.16

Data presented as mean +/- standard deviation or median (interquartile range). Postop = postoperative; EF = ejection fraction; VSD = ventricular septal defect; BSA = body surface area; Ao = aorta; LV = left ventricular; VTI = velocity time integral; VCFc = velocity of circumferential fiber shortening corrected for heart rate

P1-52

Transgenerational Implications of Gestational Diabetes and Maternal Adiposity for Offspring Body Composition and Diastolic Function: 6 Years Follow-up

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Background: Gestational diabetes (GDM) and maternal adiposity are associated with offspring cardiovascular risks including disturbed diastolic heart function. Fetal programming has been considered as an underlying mechanism. We aimed to investigate the influence of GDM and maternal adiposity on child body composition and diastolic heart function 6 years postpartum. **Methods:** The observational follow-up study included 201 mother-child pairs (boys, n=111), a subcohort from the RADIEL - Finnish Gestational Diabetes Prevention Study. Mothers and children were recruited at a mean of 6,1 (+/- 0,5) years postpartum. GDM was diagnosed in 96 mothers, 36 of whom required oral or insulin treatment. The follow-up assessment included child echocardiography, child and maternal anthropometrics, body composition assessed with bioelectrical impedance and blood pressure. **Results:** Maternal height, lean body mass and body fat mass were mirrored in offspring. Maternal pre-pregnancy body mass index (BMI 30,5 +/- 5,6 kg/m^2) correlated with child BMI z-score (r=0,2; p=0,006; mean z-score 0,45 +/- 0,93 kg/m^2 in relation to a national population). Left atrial volume (LAV) correlated with child age, anthropometrics and body composition (Table 1). In a stepwise linear regression model LAV was independently predicted by child lean body mass and body fat percentage (R^2=0,283). Pulmonary vein flow systolic to diastolic ratio (S/D) and mitral annular velocity during atrial filling (A') correlated with child waist-height ratio, BMI z-score and body fat percentage (Table 1). LAV index (LAV/body surface area) correlated with S/D and A' (r=0,2; p=0,01 and r=0,2; p=0,005 respectively). LAV, LAV index, S/D and A' were not associated with pre-pregnancy BMI or GDM exposure. Lean body mass was higher (p=0,002), but S/D and body fat percentage lower (p=0,02 and p<0,001, respectively), in boys compared with girls - although LAV, LAV index and A' were not different. **Conclusion:** Child diastolic heart function at six years of age is influenced by child adiposity. Maternal pre-gestational adiposity is reflected in child body composition, increasing long-term cardiovascular risks and disturbing diastolic heart function. However, no evidence of fetal programming related to GDM was found in early childhood.

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	LAV		LAV index		S/D		A'	
	r	p-value	r	p-value	r	p-value	r	p-value
Age	0,16	0,03						
Height	0,42	<0,001						
Weight	0,53	<0,001						
BMI z-score	0,43	<0,001			0,15	0,003	0,22	0,002
Waist-height ratio	0,16	0,02			0,19	0,006	0,27	<0,001
Lean body mass	0,51	<0,001						
Body fat mass	0,46	<0,001						
Body fat percentage	0,25	<0,001			0,21	0,003	0,19	0,007
SBP z-score			-0,21	0,004				
DBP z-score			-0,18	0,01				
Maternal height	0,2	0,006						
Maternal lean body mass	0,28	<0,001						

P1-53

Three-Dimensional Echocardiography is an Important Additive Tool to Two-Dimensional Imaging in Pre-Operative Assessment of Pediatric Atrioventricular Valve Disease

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Background: Advances in three-dimensional echocardiography (3DE) have led to recommendations that it be used in pre-operative planning for congenital or acquired heart disease as a complementary non-invasive tool to two-dimensional echocardiography (2DE). The purpose of this study is to evaluate our institutional experience in 3DE providing additive and important anatomic details compared to 2DE since inclusion of 3DE into the pre-operative work flow for specific lesions. **Methods:** Retrospective single center review of 57 3DE studies occurring 7/2015-2/2017, coinciding with initiation of standard 3DE pre-operative imaging in addition to 2DE for unrepaired atrioventricular septal defects (AVSD), repaired AVSD with atrioventricular valve dysfunction, mitral valve (MV), or tricuspid valve (TV) anomalies. All studies were performed on Philips iE33 or Siemens Acuson SC2000 transthoracic or transesophageal platforms. Patient demographics, study date, vendor, and probe type were recorded. Lesion-specific anatomic variables were assessed for presence in diagnostic reports and from this the 3DE studies were determined as additive if new information was present, complementary if no new data was found, or neither. Data grouping and demographics were described, and McNemar tests were used for paired grouping comparisons between 2DE and 3DE findings. **Results:** 56/57 studies contained 3DE imaging of diagnostic quality with complete reports. Most patients were <1 year old (46%) and female (57%). The Philips 3DE transthoracic probe was used most often. The most common lesion imaged was unrepaired AVSD (32%). Additive information was present in 98% of the 3DE studies and the remainder were complementary. All AVSD and TV studies were deemed additive. In unrepaired AVSD, the additional 3DE findings of significance included description of leaflet size (p<0.001), leaflet number (p=0.004), commissures (p<0.001), coaptation (p=0.039), subvalvar apparatus (chordae p=0.016, papillary muscles p=0.001), and site of regurgitation (p=0.001). Similarly, in TV studies the significant findings were description of leaflet size (p=0.008), leaflet number (p=0.031), commissures (p=0.031), chordae (p=0.031), and site of regurgitation (p=0.016). **Conclusion:** 3DE is an important and readily-available tool in the pre-operative evaluation of pediatric atrioventricular valve disease, frequently describing key additive details about valve morphology and function that is not included in 2DE reports. Providing this information to surgeons should be standard practice for congenital heart centers.

P1-54

Echocardiographic Indices to Improve the Prenatal Diagnosis of Coarctation of the Aorta

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Background: Prenatal diagnosis of coarctation of the aorta is difficult and historically carries a high false positive rate. Early, accurate diagnosis is important given the associated mortality and morbidity of an undetected coarctation. The aim of this study was to identify fetal echocardiographic measures that serve as predictors of postnatal coarctation. **Methods:** This was a retrospective review of three groups of patients from 2013 to 2017: 1) Prenatal diagnosis of coarctation confirmed postnatally (n=13), 2) Prenatal diagnosis of coarctation with normal arch postnatally (n=14), and 3) controls (n=30). Measurements were made on all available fetal echocardiograms for each patient, including: diameters of the ascending aorta, proximal transverse arch, distal transverse arch, aortic isthmus, left common carotid artery (LCA); and distances between the brachiocephalic to LCA (BC-LCA) and the LCA to left subclavian artery (LCA-LSCA). The following previously validated postnatal indices were applied to our fetal echocardiograms: LCA to distal transverse arch diameters (LCA/DT), distal transverse arch diameter to LCA-LSCA distance (DT/LCA-LSCA), and left to right ventricle diameters. Linear mixed effects models were used to examine the between-group differences in the trajectories of the measurements. **Results:** Significant differences were seen in group 1 (postnatal coarctation) for the following: smaller DT/LCA-LSCA index (p<0.03), smaller proximal transverse arch diameter (p<0.05), and longer BC-LCA (p<0.03) and LCA-LSCA distances (p<0.0001). The aortic isthmus (p<0.0001) and left to right ventricle diameter ratio (p<0.02) were significantly smaller in both groups 1 and 2 as compared to controls, but could not differentiate between them. As gestation progresses, the LCA/DT index trend appears to differentiate group 2 from group 1. The LCA/DT index increases over time for group 2 while it decreases for group 1 (p<0.03). **Conclusion:** The fetal echocardiographic DT/LCA-LSCA index, as well as BC-LCA and LCA-LSCA distances are significant predictors of postnatal coarctation. The LCA/DT index trend over time can help differentiate which of those patients with prenatal concern for coarctation are more likely to develop coarctation postnatally. The use of simple fetal echocardiographic markers may improve prenatal detection and accurate predication of postnatal coarctation.

P1-55

Assessment of Right Ventricular-Pulmonary Circulation Coupling in Neonates with Pulmonary Hypertension

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Background: Congenital diaphragmatic hernia (CDH) and persistent pulmonary hypertension (PPHN) exert significant load to the right heart and affect right ventricular-pulmonary circulation coupling, that can be assessed with the length-force relationship (tricuspid annular plane systolic excursion [TAPSE] vs. pulmonary artery systolic pressure). Pulmonary artery acceleration time (PAAT) is a validated echocardiographic surrogate of pulmonary artery systolic pressure. The purpose of this study was to test the hypothesis that the length-force relationship (TAPSE*PAAT, cm*ms) is diminished in neonates with CDH and/or PPHN. **Methods:** Retrospective study of 48 full term neonates with CDH and/or PPHN and 29 controls. TAPSE (cm) was used to measure right ventricular length shortening and PAAT (ms) to estimate pulmonary artery systolic pressure for generated force (afterload) at <5 days and 2-3 weeks of age. PAAT was also indexed to right ventricular ejection time (RVET) to correct for heart rate. Echocardiographic parameters were used to classify the neonates in three groups based on pulmonary-to-systemic pressure relationship as < 2/3 systemic (group 1), 2/3 systemic-systemic (group 2) and ≥ systemic (group 3), and included: ductus arteriosus flow direction and velocity, tricuspid regurgitation jet velocity, and ventricular septum position in systole. **Results:** At baseline, neonates in group 3 had the lowest TAPSE (p<0.001). Groups 2 and 3 had lower values of PAAT and PAAT/RVET (p<0.02 for both). Both TAPSE*PAAT and TAPSE*(PAAT/RVET) were significantly lower in group 3 (p<0.001 for both). At 2-3 weeks of age, following CDH repair and treatment of PPHN, patients that remained in group 3 continued to have the lowest TAPSE (p=0.03). PAAT/RVET was similar between the groups (p=0.13), but the TAPSE*PAAT and TAPSE*(PAAT/RVET) remained lower in groups 2 and 3 ($p \leq 0.01$) (Table). **Conclusion:** Neonates with CDH and/or PPHN with ≥ 2/3 systemic estimated pulmonary artery systolic pressure at 2-3 weeks of age exhibit ongoing abnormal right ventricular-pulmonary circulation coupling, reflective of a maladaptive response of the ventricular function to changes in afterload. Persistence of altered right ventricular-pulmonary circulation coupling warrants long-term follow-up for risk stratification.

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Table: Baseline clinical and echocardiographic characteristics (< 5 days of age)				
	Group 1 n = 14	Group 2 n = 25	Group 3 n = 38	p
Gestational age at birth, weeks	39 ± 1	39 ± 1	39 ± 1	0.95
Age, days	2.3 ± 1.3	1.6 ± 1.3	1.3 ± 1.3	0.02†
Gender, male	8 (57%)	12 (48%)	25 (66%)	0.37
Weight, Kg	3.2 ± 0.5	3.6 ± 0.6	3.8 ± 0.8	0.03†
Heart rate, bpm	133 ± 20	129 ± 24	145± 25	0.02‡
Mechanical ventilation, n	0	7 (28%)	27 (71%)	
FiO2	0.21 ± 0	0.42 ± 0.24	0.67 ± 0.31	<0.0001†‡
iNO	0	7 (28%)	27 (71%)	
On inotropes, n	0	6 (24%)	28 (73%)	
Baseline echocardiographic indicators of ventricular function				
TAPSE, cm	0.75 ± 0.17	0.71 ± 0.16	0.57 ± 0.17	0.001†‡
RV MPI	0.24 ± 0.12	0.29 ± 0.13	0.47 ± 0.20	<0.001 †‡
LV MPI	0.27 ± 0.15	0.30 ± 0.12	0.37 ± 0.21	0.15
Baseline echocardiographic indicators of pulmonary hypertension				
Flattened ventricular septum in systole	0	21 (84%)	37 (97%)	
Adequate TR jet to measure ESPAP	0	2 (8%)	13 (34%)	
PDA present	3 (21%)	12 (48%)	33 (87%)	
PDA right to left in systole	0	0	32 (97%)	
PAAT, ms	79 ± 18	67 ± 19	51 ± 11	<0.001 *†‡
RVET, ms	205 ± 20	207 ± 27	168 ± 29	<0.001†‡
PAAT/RVET	0.39 ± 0.09	0.32 ± 0.08	0.31 ± 0.09	0.017*†
TAPSExPAAT, cm*ms	60 ± 24	49 ± 19	30 ± 12	<0.001†‡
TAPSE*(PAAT/RVET), cm	0.30± 0.11	0.23± 0.08	0.18 ± 0.07	<0.001*†‡
Clinical and echocardiographic characteristics at 2-3 weeks of life				
	n = 15	n = 14	n = 8	
Age, days	18 ± 11	18 ± 6	20 ± 9	0.9
Heart rate, bpm	150 ± 16	156 ± 17	163 ± 21	0.23
Mechanical ventilation, n	3 (20%)	5 (36%)	6 (75%)	
FiO2	0.24 ± 0.06	0.38 ± 0.20	0.59 ± 0.32	0.001*†
iNO	1 (7%)	6 (43%)	7 (88%)	
On inotropes, n	0	3 (21%)	5 (63%)	
Echocardiographic indicators of ventricular function at 2-3 weeks of life				
TAPSE, cm	0.77 ± 0.18	0.67 ± 0.22	0.52 ± 0.10	0.025†
RV MPI	0.18 ± 0.09	0.14 ± 0.09	0.45 ± 0.19	0.02†‡
LV MPI	0.28 ± 0.12	0.25 ± 0.10	0.17 ± 0.05	0.09
Echocardiographic indicators of pulmonary hypertension at 2-3 weeks of age				
Flattened ventricular septum in systole	0	13 (92%)	8 (100%)	
Adequate TR jet to measure ESPAP	2 (21%)	3 (21%)	3 (38%)	
PDA present	2 (13%)	3 (20%)	3 (37%)	
PDA right to left in systole	0	0	3 (100%)	
PAAT, ms	79 ± 15	65 ± 14	62± 19	0.02*†
RVET, ms	198 ± 17	191 ± 17	158 ± 40	0.02†‡
PAAT/RVET	0.40 ± 0.08	0.34 ± 0.07	0.40 ± 0.12	0.13
TAPSExPAAT, cm*ms	62 ± 16	42 ± 15	34 ± 14	0.001*†
TAPSE*(PAAT/RVET), cm	0.30± 0.08	0.22 ± 0.08	0.22 ± 0.06	0.02*†

All results reported as mean ± SEM or N (%). * p < 0.05 between group 1 and group 2, p < 0.05 between group 1 and group 3, à p < 0.05 between group 2 and group 3 ESPAP: estimated pulmonary artery systolic pressure, MPI: myocardial performance index

P1-56

Left Atrial and Ventricular Mechanics in a Cohort of Hypertensive Children Compared to Age, Sex and Race Matched Controls

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Background: Few studies have evaluated echocardiographic abnormalities and specifically left atrial (LA) changes in children with systemic hypertension (HTN). In the adult literature, markers of abnormal systolic function including left ventricular (LV) mass and hypertrophy are predicative of adverse cardiovascular events. Similarly, LA volume and strain, which are reliable indicators of diastolic dysfunction and severity, have also been shown to predict cardiovascular and all-cause mortality. This study is the first to describe LV and LA mechanics in a hypertensive pediatric population in comparison to matched controls. **Methods:** Data was collected from all first patient visits to the HTN Program at the Children's Hospital of Philadelphia from 12/2011 to 12/2015. Patients with HTN were defined as having abnormal ambulatory blood pressure monitor results (76 patients). Patients with coarctation of the aorta, heart transplant, or cardiomyopathy were excluded (20). Controls were matched to cases by age, sex, and race. LA volume was measured by biplane method, indexed to BSA. LA longitudinal global strain was measured using TomTec software. LV septal (IVSD) and posterior wall thickness (PWT) were measured with z-scores by m-mode. LV mass index (LVMI) was measured by m-mode and with the 5/6 area length method indexed to height$^{2.7}$. Matched pairs with complete data for each outcome were compared using paired t-tests. P-values<0.05 were considered significant. **Results:** There was no difference in LA strain or LA volume in the hypertensive patients in comparison to controls (p-value 0.906 and 0.055, respectively). There was, however, a statistically significant difference in septal E/e' ratio (p value=0.007). IVSD, PWT and LVMI were significantly higher in hypertensive patients (p-values <0.001, 0.004 and <0.001, respectively). (Table 1). **Conclusion:** Markers of LV hypertrophy, including LVMI were significantly elevated in hypertensive patients compared to controls. Interestingly, the septal E/e' ratio, a marker of diastolic function, was significantly higher in hypertensive patients, but there was no difference in the LA volume or strain. These findings indicate that while changes in LA mechanics may occur later in life, LV hypertrophy appears to be an early finding in younger hypertensive patients.

		CASES		CONTROLS		
	N*	Mean	STD	Mean	STD	P-value
AGE (YEARS)	56	14.2	4.0	14.2	4.0	0.981
BSA (M^2)	56	1.6	0.4	1.6	0.6	0.593
LA STRAIN (%)	53	38.8	11.7	38.5	7.0	0.908
LA VOLUME BIPLANE (ML/M^2)	46	23.7	7.5	26.5	7.0	0.055
LVMI BY M-MODE ($G/M^{2.7}$)	53	42.1	11.5	33.3	6.7	<0.001
LVMI BY 5/6 AREA LENGTH ($G/M^{2.7}$)	46	30.0	7.9	25.1	5.1	<0.001
PWT Z-SCORE	51	0.1	1.4	-0.5	0.7	0.004
IVSD Z-SCORE	48	0.2	1.2	-0.7	0.8	<0.001
SEPTAL E/E' RATIO	50	8.5	2.5	7.4	1.5	0.007

*Total number of matched pairs with data available for each measure

P1-57

Diastolic Dysfunction in Tetralogy of Fallot: Comparison of Echocardiography with Cardiac Catheterization

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Background: Right ventricular (RV) systolic dysfunction has been associated with adverse outcomes in tetralogy of Fallot (TOF). However, the role and etiology of diastolic dysfunction remains incompletely defined. We sought to assess the association between echocardiographic measures of diastolic function with catheter-based RV end-diastolic pressure (RVEDP) and identify clinical characteristics independently associated with diastolic dysfunction. **Methods:** This is a single-center, retrospective study of surgically repaired TOF patients undergoing cardiac catheterization with echocardiograms within three months prior to catheterization. Diastolic dysfunction was defined on echocardiogram by tricuspid inflow and tissue Doppler measurements (E/A, E/e', and deceleration time), and on catheterization by RVEDP ≥10 mmHg. Linear and logistic regression analyses tested associations between echocardiographic parameters, RVEDP, and clinical characteristics. **Results:** Ninety-four subjects were included. Age at catheterization was 8.9 years (Interquartile range (IQR) 4.4, 15.9). RVEDP at catheterization was 9.5±2.5 mmHg with 48 (51%) having an RVEDP ≥10mmHg. Sixty-one subjects (65%) had echocardiographic evidence of diastolic dysfunction. RVEDP was not associated with any individual echocardiographic parameter or when those parameters were combined to define diastolic dysfunction (Figure). There was poor agreement between an elevated RVEDP and the presence of diastolic dysfunction by echocardiogram (Kappa = 0.04). Likewise, there was poor agreement between RVEDP and E/e' (Kappa = 0.04). Higher RVEDP was directly associated with larger right atrial area and RV end-diastolic area, independently of weight and degree of pulmonary or tricuspid regurgitation (R^2 = 0.13, p=0.001 and R^2=0.08, p=0.05, respectively). Greater number of interim procedures was associated with higher RVEDP, E/e', and diastolic dysfunction by echocardiography. **Conclusion:** Diastolic dysfunction, as determined by echocardiography-derived measures and catheter-based measures (RVEDP), is prevalent in this pediatric population of TOF; However, these parameters are not associated with each other. Future research is needed to develop noninvasive parameters associated with filling pressures in this population.

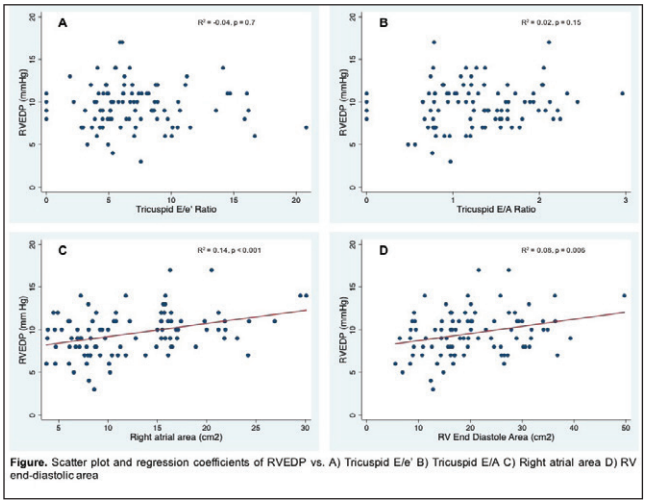

Figure. Scatter plot and regression coefficients of RVEDP vs. A) Tricuspid E/e' B) Tricuspid E/A C) Right atrial area D) RV end-diastolic area

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P1-58

Impact of Pre-Operative Echocardiographic Assessment of Single Ventricle Diastolic Function on Post-Operative Outcomes after the Fontan Operation

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Background: Post-operative complications after the Fontan operation for single ventricle congenital heart disease are common, and include persistent pleural drainage and extended length of hospital stay (LOS). Diastolic ventricular dysfunction is common in the single ventricle population, and may increase the risk for post-op complications as a result of increased central venous pressures and pleural drainage. We sought to determine the relationship between pre-operative diastolic myocardial deformation imaging and Doppler-derived echocardiographic measurements of diastolic function with (1) pre-operative invasive catheterization measurements, and (2) post-operative outcomes after the Fontan procedure. **Methods:** All patients that underwent Fontan procedure at our institution from 2011 to 2017 were included. Pre-operative echocardiograms performed within 6 months prior to Fontan operation were evaluated. Retrospective measurements of diastolic strain and strain rate were performed off-line with TomTec speckle tracking software. Other quantitative echo measurements included atrioventricular valve inflow and annular tissue Doppler imaging. Echo measurements were correlated with pre-Fontan catheterization measurements and post-operative Fontan outcomes using Spearman Rho. Multivariable logistic regression for a prolonged LOS (>75%ile for post-operative LOS) was performed to adjust for preoperative risk factors. **Results:** A total of 141 patients were included with 10 excluded for inadequate image quality for complete endocardial tracking. Majority had single morphologic right ventricle (58.9%). Median age at time of Fontan was 3.4 (IQR 2.9-4) years, and 98.6% were extracardiac with 88% fenestrated. Median hospital LOS was 9 days (IQR 7-11). Circumferential diastolic strain weakly correlated with LOS (rho= -0.21, p=0.01). There was no correlation between any other diastolic strain measurements and pre-Fontan end-diastolic pressure, post-op LOS, or chest tube duration. In multivariable analysis, E/e' was the only echo measurement that predicted prolonged hospital LOS (OR 1.4, 95%CI: 1.1-1.8, p 0.003). **Conclusion:** Pre-op diastolic strain measurements did not have a strong association with post-op Fontan outcomes. Increased E/e' ratio, however, did predict greater LOS after Fontan procedure, and may be useful as part of pre-operative risk stratification. Future studies are needed to further understand the utility of diastolic strain imaging in the single ventricle population.

P1-59

Prenatal Isthmus to Ductus Ratio and Atrial Septal Configuration Improves Prediction of Fetal Diagnosis of Coarctation of the Aorta Over Traditional Parameters

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Background: Prenatal right-left ventricular size discrepancy (RLVD) is a common reason for fetal echocardiographic evaluation, as it can be a sign of left-sided obstructive lesions such as coarctation of the aorta (CoA). Previous reports have demonstrated only moderate sensitivity and low positive predictive value for its ability to predict significant postnatal CoA. We sought to evaluate the utility of traditional markers of RLVD, and whether other secondary markers of abnormal flow across the aortic arch or foramen ovale would improve the ability to predict the presence or absence of neonatal coarctation. **Methods:** Fetal echocardiograms from mothers referred to our tertiary institution from Jan 2010-Oct 2017 for isolated RLVD were analyzed. 2-dimensional data of cardiac chambers, valves, and extracardiac vessel size was obtained and adjusted for gestational age using published Z-scores. Parameters were evaluated for their ability to predict the presence of critical coarctation, defined as the need for surgical coarctation repair in the neonatal period (<30 days). **Results:** A total of 36 fetal echocardiograms from twenty five patients who had both prenatal and postnatal data available were analyzed. Median (range) fetal gestational age for the entire cohort was 32.6 (22.7-37.4) weeks. Nine (36 %) of the fetuses had critical arch obstruction requiring neonatal CoA repair. There was no significant difference in right ventricular or left ventricular diameters, tricuspid, mitral, or pulmonary valve sizes between the CoA and non-CoA groups. The aortic valve and aortic isthmus diameters were smaller in the CoA group (Z -3.4 vs Z -2.1, P <0.05, and Z -2.2 vs Z -1.3, P <0.05). A 3-vessel view (3VV) isthmus:ductal ratio ≤ 0.67 was a highly specific measure to predict need for neonatal coarctation intervention (see Table 1). Additionally, a redundant septum primum bowing into the left atrium, present in 11/16 (69%) of the non-CoA group but none of the positive CoA patients, was highly suggestive for the absence of coarctation. **Conclusion:** Traditional chamber and size measurements of RLVD may be similar between fetuses with and without neonatal CoA. An abnormal 3VV isthmus:ductal ratio and changes in atrial septal configuration may improve the ability to predict the need for neonatal CoA repair beyond traditional parameters.

Table 1

Parameter	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)
3VV ≤ 0.67	67% (30-93%)	100% (79-100%)	100% (77-100%)	84% (68-93%)

P1-60

Utility Of Multi-Modality Imaging For Evaluation Of Aortic Arch Anatomy In Individuals With 22q11.2 Deletion Syndrome

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Background: About two-third of patients with 22q11.2 deletion syndrome have a congenital cardiovascular defect [CVD], primarily conotruncal and aortic arch [arch] anomalies. It is recommended to obtain an echocardiogram [echo] upon diagnosis. Thorough evaluation of arch sidedness and brachiocephalic branching is important to diagnose and treat interrupted arch, vascular ring and for planning systemic to pulmonary artery shunts. Echo evaluation of arch, in these patients has specific challenges due to diverse pathology, paucity of thymus tissue and difficult echo windows. Our study aimed to evaluate the accuracy of echo in identifying arch anatomy. **Methods:** This retrospective study included patients with 22q11.2 deletion who have participated in our inter-disciplinary 22q11.2 deletion clinic data repository. We reviewed the charts of 113 patients (age 3months - 18 years). Patients without CVD and patients who did not have CT/MR or catheter angiograms [angio] for comparison were excluded. Right sided arch and interrupted aortic arches were grouped as abnormal arch anatomy. We compared initial echo as a screening test to any available angio as gold standard. In 2012, we instituted arch echo imaging sweeps in parasagittal and paracoronal planes from suprasternal notch, as arch imaging protocol. Sensitivity and specificity for echo diagnosis of abnormal arch were calculated using 2x2 tables and were compared before and after 2012. **Results:** 63 patients (65%) had an echo diagnosis of CVD. Out of these patients, 57 had additionally some form of aortic angio performed. Prior to 2012, echo only accurately diagnosed 6 out of 12 abnormal arches with a sensitivity of 50%. After 2012, 22 out of 22 abnormal arches were accurately diagnosed, with a sensitivity of 100%. There were 2 false positives with a specificity of 83%, positive predictive value of 91% and negative predictive value of 100%. Cervical arch, circumflex or tortuous arch anatomy was largely responsible for echo v/s angio discrepancy (figure). **Conclusion:** Echo with appropriate imaging sweeps is the modality of choice for screening aortic arch pathology in 22q11.2 deletion. CT/MR angio should be used to confirm or complement echo for optimal arch imaging.

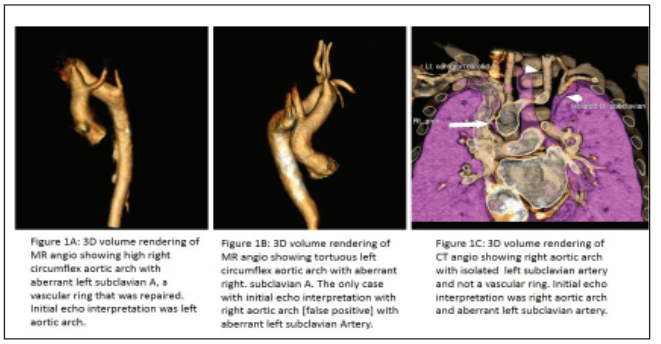

Figure 1A: 3D volume rendering of MR angio showing high right circumflex aortic arch with aberrant left subclavian A, a vascular ring that was repaired. Initial echo interpretation was left aortic arch.

Figure 1B: 3D volume rendering of MR angio showing tortuous left circumflex aortic arch with aberrant right. subclavian A. The only case with initial echo interpretation with right aortic arch [false positive] with aberrant left subclavian Artery.

Figure 1C: 3D volume rendering of CT angio showing right aortic arch with isolated left subclavian artery and not a vascular ring. Initial echo interpretation was right aortic arch and aberrant left subclavian artery.

P1-61

Effects on Cardiac Size in a Prospective Study of Selective Serotonin Reuptake Inhibitors

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Background: Selective serotonin reuptake inhibitors (SSRIs) are antidepressants prescribed in about 10% of pregnancies in the United States. Animal studies demonstrate SSRI exposure decreases cardiac cell proliferation. We have shown in two animal models that SSRI exposure during development reduces ventricular size and cardiac function. The purpose of this investigation was to determine if term infants exposed to *in utero* SSRIs have reductions in ventricular size or cardiac function. **Methods:** Term infants, appropriate for gestational age, with or without exposure to *in utero* SSRIs underwent standard echocardiograms including four-chamber and M-mode views within 48 hours of life to assess cardiac size and function. Additional echocardiography protocols specific to ventricular size in newborns during this transition period were employed. Exclusion criteria for infants included prematurity, large or small for gestational age, any respiratory or cardiac support, and any major congenital malformations. Maternal and infant demographics were collected from medical records. **Results:** Twenty-one infants without and 20 infants with *in utero* SSRI exposure were prospectively enrolled. As compared to unexposed infants, infants exposed to *in utero* SSRIs had an 16 ± 2% reduction in right ventricular diameter in diastole (Control 1.1 ± 0.05 cm, SSRI 0.9 ± 0.05 cm, p=0.02) and a 22 ± 2% reduction in left ventricular volume in systole (Control 1.7 ± 0.1 mL, SSRI 1.4 ± 0.1 mL, p=0.02). SSRI-exposed infants had decreased left ventricular lengths in diastole and systole [Diastole: Control 3.5 ± 0.1 cm, SSRI 3.3 ± 0.1 cm, p=0.045; Systole: Control 2.9 ± 0.1 cm, SSRI 2.6 ± 0.1 cm, p=0.004]. No difference was observed in right ventricular length. There was no difference in cardiac function as measured by shortening fraction.

Importantly, there were no differences in maternal conditions or infant birth weight, body surface area or gestational age. **Conclusion:** Our findings show that *in utero* SSRI exposure was associated with decreased left ventricular dimensions at birth. Considering the importance of early life programming during critical periods of development on future cardiac health and disease risk, larger studies need to be completed to determine the long-term implications of SSRI exposure on ventricular size.

P1-62

Tricuspid Leaflet-Annular Disproportion in Hypoplastic Left Heart Accentuates Tenting While Maintaining Normal Coaptation Distances

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Background: Tricuspid valve (TV) dysfunction in hypoplastic left heart syndrome (HLHS) is associated with increased morbidity and higher risk of cardiac transplantation or death. Annular and leaflet changes have been postulated as causes of TV dysfunction. Using three-dimensional echocardiography (3DE), we sought to comprehensively characterize geometry, structure and function of TV annulus and leaflets in HLHS compared to age and gender matched normal controls. **Methods:** 3DE was prospectively performed using the iE33 system (Philips). Full-volume acquisitions of the TV and right ventricle (RV) were performed from an RV-focused apical view using ECG gating over 2-5 consecutive cardiac cycles. Annular [area, perimeter, circularity, dimensions at late diastole, inter-commissural distances in mid systole] and leaflet parameters [tenting height, tenting volume, areas (anterior, posterior, septal, total), coaptation distances (anteroseptal, posteroseptal, anteroposterior)] were measured using custom software. **Results:** In all, 80 subjects were studied consisting of 40 HLHS (17/23 female/male, age 1.0±1.5 years, body surface area (BSA) 0.4±0.2 m^2), and 40 age and gender matched controls (age 1.0±1.5 years, BSA 0.4±0.2 m^2). Among HLHS patients, 7 were pre-Norwood, 19 pre-Glenn, 10 pre-Fontan and 4 post-Fontan. All annular parameters for HLHS except annulus length in short axis were similar to controls. Multiple leaflet parameters were larger in HLHS than controls: tenting volume 0.9±0.6 vs. 0.5±0.3ml ($p<0.001$), and all leaflet areas (anterior 1.5±1.1 vs. 0.8±0.4 cm^2, $p<0.001$; posterior 1.1±0.7 vs. 0.8±0.5 cm^2, $p<0.05$; septal 1.3±0.7 vs. 0.8±0.5 cm^2, $p<0.05$; total 4.1±1.9 vs. 2.6±1.1 cm^2, $p<0.001$); while all 3 leaflet coaptation distances were similar between the groups. **Conclusion:** Tricuspid leaflets are uniformly larger in HLHS than in normal. This leaflet-annular disproportion results in greater tenting volume in HLHS, while maintaining normal leaflet coaptation distances.

P1-63

Echocardiographic and Cardiac MRI Deformation Analysis in Patients with Single Left Ventricle vs Right Ventricle Post Fontan Surgery

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Background: Single ventricle (SV) functional assessment remains a critical component of follow up after Fontan palliation. Myocardial deformation imaging in patients post Fontan can be completed by both TTE and cardiac MRI (CMR). TTE provides the ability for real time deformation analysis that has helped characterize differences in function based on SV morphology, while CMR has the advantage of accurate volumetric and functional analysis. Data on correlation between the two modalities in this population when comparing single left ventricles (LV) vs single right ventricles (RV) is limited. **Methods:** SV patients post Fontan who had undergone TTE assessment of deformation during clinically indicated studies and had CMR within 1 year of the TTE study were included. Deformation indices included global circumferential strain (CS) and strain rate (CSR) and global longitudinal strain (LS) & strain rate (LSR); real-time values obtained during the echo study were compared with blinded measures performed retrospectively off-line from CMR imaging. **Results:** From 9/14 to 5/17, 37 patients were included (13 single LV; 24 single RV). Median age at the time of TTE was 13 years (IQR 8.5, 19). TTE deformation analysis was completed real-time in 100% of the studies. There was variable correlation between the TTE and CMR deformation indices, with correlation coefficients ranging from 0.55 for CS to 0.15 for LS. CS by both TTE and CMR was significantly higher in patients with single LV vs single RV and correlated with differences in CMR-derived SV ejection fraction (Table 1). TTE assessment of CSR also differentiated single LV from the single RV, in contrast to CMR. Longitudinal indices did not differentiate ventricular morphology using either technique, with only LS by echo approaching significance. **Conclusion:** Circumferential deformation indices acquired real time during clinical TTE appears to differentiate single LV from single RV post Fontan and should be a focus in assessing ventricular function non-invasively. CMR is complimentary to TTE in providing volumetric analysis of the single ventricle.

Table 1: Differences in TTE and CMR deformation indices between single left and right ventricles

Parameter	LV – median (IQR)	RV – median (IQR)	P-value
Global Circumferential strain			
TTE	-17.6 (-23.77 to -14.88)	-12.32 (-15.32 to -9.31)	**0.012**
CMR	-16.83 (-20.23 to -14.08)	-12.58 (-15.35 to -10.73)	**0.012**
Global Circumferential strain rate			
TTE	-1.14 (-1.53 to -1.02)	-0.9 (-1.05 to -0.63)	**0.015**
CMR	-0.98 (-1.31 to -0.73)	-0.76 (-0.94 to -0.61)	0.141
Global Longitudinal strain			
TTE	-18.11 (-19.46 to -14.05)	-14.05 (-16.8 to -11.34)	0.056
CMR	-15.09 (-19.54 to -13.58)	-14.15 (-16.57 to -9.74)	0.84
Global Longitudinal strain rate			
TTE	-1.08 (-1.15 to -0.78)	-0.87 (-1.02 to -0.66)	0.156
CMR	-1.03 (-1.44 to -0.7)	-0.85 (-1.05 to -0.7)	0.16
Ejection Fraction (CMR)	65	51.45	**0.012**

P1-64

Age Related Changes in Indexed Inferior Vena Cava Dimensions Among Syncopal Children and Adolescents

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Background: Dilation of the inferior vena cava (IVC) in the absence of volume overload or right heart disease is a marker for depressed venous tone. Evidence is accumulating to support altered venous compliance as a major pathophysiologic mechanism for syncope in adults. We measured IVC diameter in young syncopal patients and controls in order to test the hypothesis that increased venous compliance manifested as IVC dilation is an important substrate for syncope in children and adolescents. **Methods:** Long Axis IVC diameters were measured in 191 children and adolescents with normal hearts who had echocardiograms recorded as part of an evaluation for syncope and in 95 controls. Subjects were divided into subgroups based on age < 12 years (Younger) and ≥ 12 years (Older). IVC measurements (in triplicate and averaged) at right atrial junction (IVC-RA), 10 mm below IVC-RA junction (IVC-RA10), and IVC at point of maximal diameter (IVCmax) were made in subcostal coronal and sagittal views (Figure). The linear relation of IVC parameters to body surface area (BSA) was confirmed in the control group using linear regression. IVC parameters were then indexed to BSA (iIVC). Comparisons of continuous variables were made using Student t-test, and binary variables using chi square test. **Results:** Mean ± standard deviation age, height, weight, and BSA in the syncope patients were 12.9 ± 3.6 years, 156.6 ± 21 cm, 54.7 ± 23 kg, and 1.5 ± 0.4 m^2, respectively. There were no significant differences between the syncope and control groups in gender, age, height, weight, and BSA. Among controls, all IVC parameters varied linearly with BSA ($p<0.001$ for all regressions). In the Older Group, containing 140 syncope patients and 60 controls, all indexed IVC parameters were larger in the syncope cohort iIVC-RA 9 vs. 7.7 mm/m^2, $p<0.0001$; iIVC-RA10 9.4 vs. 8.1 mm/m^2, $p<0.0001$; iIVCmax 11.7 vs. 10.6 mm/m^2, $p=0.002$. In the Younger Group, containing 51 syncope patients and 35 controls, there were no significant differences in indexed IVC parameters from the syncope cohort (listed first) and controls: iIVC-RA 10.2 vs. 11.3 mm/m^2; iIVC-RA10 11.7 vs. 12.0 mm/m^2; iIVCmax 14.2 vs. 14.7 mm/m^2, all $p>0.05$. **Conclusion:** The indexed IVC diameter is enlarged in the Older Group of pediatric syncope patients, as it is in adults, suggesting that venous capacitance and resultant venous pooling plays a major role in the pathogenesis of syncope at this age. In contrast, younger children with syncope do not demonstrate IVC dilation, and this suggests their syncope likely arises from a different mechanism.

P1-65

Global Longitudinal Strain of Left Ventricle is a Strong Predictor of Significant Right Ventricular Dilatation in Tetralogy of Fallot Patients After Repair

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Background: Pulmonary regurgitation after repair of tetralogy of Fallot (TOF) is one of the major sequellae, which requires re-operation before the significant right ventricular dysfunction develops. The appropriate timing of re-operation for right ventricular outflow tract reconstruction has been determined based on the right ventricular volume measured by cardiac magnetic resonance imaging (CMR). However, CMR is costly and has several limitations, which hamper its usage on daily practice. Echocardiography is an ideal imaging modality enabling assessment of ventricular size and function on daily practice without major limitations. 2D global longitudinal strain imaging (GLS) has established its utility on the assessment of ventricular function and predictive value for clinical outcome. The objective of this study is to investigate the correlation between right ventricular volume analyzed by CMR and strain data in TOF patients after repair. **Method:** This is a retrospective cohort study on 89 TOF patients after repair with CMR assessment. We excluded the patients with significant residual right ventricular outflow

tract obstruction (peak velocity>3m/s), or poor echocardiographic image quality. The following parameters were analyzed by CMR and echocardiography: 1) CMR: right ventricular end-diastolic volume index (RVEDVI (RVEDV/BSA), RV end-systolic volume index, RV ejection-fraction (RVEF), pulmonary regurgitant fraction (PR fraction); 2) Echocardiography: RV fractional area change (RV FAC), RV free-wall strain, RV GLS, LVEF, and LV GLS. 2D strain analyses were performed by 2D Cardiac Performance Analysis (TOMTEC). **Results:** We included 30 patients for analysis (male 17: female 13: age: median (range): 14.6(4.9-21.0)). The RV outflow tract was reconstructed by trans-annular patch in 13 patients, and the pulmonary annulus was preserved in 17 patients. There was a significant correlation between RVEDVI and PR fraction (r = 0.63), or RVEF (r=-0.65). Although the correlations between RVEDVI and RV free-wall strain, RV FAC, or RV-GLS were all weak, LV GLS showed significant correlation with RVEDVI (r = 0.79), which was the strongest among all echo parameters. The cut-off value of LV GLS was set >-17% to determine the RVEDVI>160 which is widely used criteria for pulmonary valve replacement with sensitivity 75% and specificity 93%. **Conclusion:** The most significant determinant of RVEDV was interestingly LV GLS among all echo-parameters. LV GLS may be useful to determine the appropriated timing for CMR or can be a surrogate for CMR to have re-operation.

P1-66

Longitudinal Changes in Single Right Ventricle Function in Hypoplastic Left Ventricle Syndrome and its Variant Following Hybrid Procedure: Does Forward Flow Through Aortic Valve Matter?

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Background: Hybrid procedure is a palliative procedure in Hypoplastic left heart syndrome (HLHS) and variants consisting of bilateral pulmonary artery banding and ductus arteriosus stenting. Data on its effects on single right ventricular (RV) function in HLHS are lacking. Neonates with forward flow through the aorta will have preserved blood supply to coronaries, possibly impacting function. We assessed the effects of a hybrid procedure on RV function using speckle tracking echocardiography (STE-ECHO) and hypothesized that RV function would be preserved in patients with forward flow across the left ventricular outflow tract compared to those without forward flow. **Methods:** In this retrospective study, ECHOs of neonates with HLHS and variants who underwent hybrid procedure were compared pre-procedure and at 2 time points after (post 1:1 month, post 2: pre 2nd stage repair). ECHOs were analyzed by a single reader for speckle RV longitudinal strain (GLS) and strain rate (Tomtec Inc.). Global peak systolic strain (end systole at closure of aortic valve), single plane end-diastolic and end-systolic volume, and post-systolic strain index (PSS) were measured. PSS index is a marker of ischemia and represents shortening of the segments after aortic valve closure. Comparisons between groups with and without forward flow used student t-test and Chi-square test. **Results:** Our cohort (n=31) included 17 (55%) neonates with forward flow. There were 15 (48%) males, and mean ±SD age of procedure was 9.6±5.4 days at a weight of 3.1±0.6 kg. There was a significant decrease in GLS% from before to one month after the procedure (-15.1± 3.4 vs. -11.8± 4.3, p =0.006) but no interval change until 2nd stage palliation (-11.8± 4.3 vs. -11.5±3.9, p=0.5). There were no differences in RV function as assessed by GLS or PSS in subgroups with and without forward flow (Table). End-diastolic and end-systolic volumes were significantly higher in the group without forward flow. **Conclusion:** In neonates with HLHS, there is a deterioration in RV function following hybrid procedure as reflected in strain indices on STE- ECHOs. RV function was comparable in subgroups with and without forward flow at all time points, suggesting that RV dysfunction following the procedure may be related to stress on the single ventricle secondary to pulmonary artery banding.

Demographic and Echo parameters	No Forward Flow (n=14)	Forward Flow (n=17)
Age at Hybrid	10.6 ± 4.3	8.7± 6.2
Gender (male)	7 (50%)	8 (47 %)
	Pre-Hybrid	
Weight (kg)	2.92 ± 0.63	3.21± 0.65
Height (cms)	49 ± 3.2	49 ± 4.7
Endo GLS %	-15.3 ± 2.87	-14.91 ± 2.82
Myo GLS %	-11.3 ± 2.25	-12.24 ± 3.61
EDV (ml)	9.89 ± 3.14	9.0 ± 3.52
ESV (ml)	6.05 ± 2.1	6.12 ± 2.21
PSS	1.74 ± 0.12	1.73 ± 0.11
Follow Up 1	**Post 1 month**	
Endo GLS %	-11.65 ± 5.01	-11.99 ± 3.57
Myo GLS %	-8.9 ± 4.06	-9.64 ± 3.5
EDV (ml)	**14.88 ± 3.38**	**10.63 ± 4.5***
ESV (ml)	**10.32 ± 3.25**	**7.93 ± 3.2 ***
PSS	1.07 ± 0.3	1.08 ± 0.44
Follow Up 2	**Post 3 months**	
Endo GLS %	-11.13 ± 4.73	-11.73 ± 3.12
Myo GLS %	-8.44 ± 3.95	-9.40 ± 2.96
EDV (ml)	**23.8 ± 6.67**	**14.06 ± 5.01***
ESV (ml)	**16.56 ± 5.67**	**10.67 ± 3.88***
PSS	1.67 ± 0.53	1.77 ± 1.2

*P< 0.05

P1-67

Prenatally Diagnosed Coronary Artery Fistulae in Hypoplastic Left Heart Syndrome are Associated with a Higher Probability of Heart Transplantation

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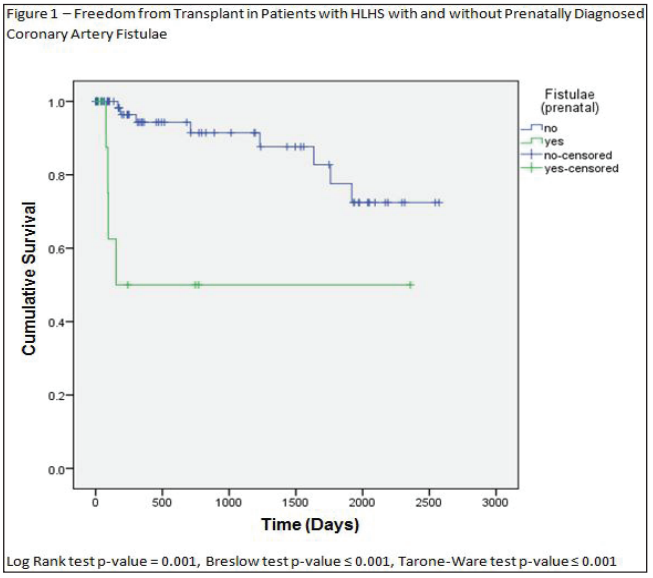
Background: Coronary artery fistulae (CF) are known to occur in patients with hypoplastic left heart syndrome (HLHS) and may be associated with higher mortality; those patients with extensive coronary abnormalities may require heart transplantation (OHT). The severity of coronary abnormalities identified prenatally may differ from those identified postnatally. We aimed to determine whether fetuses with HLHS and a prenatal diagnosis of CF have a higher risk of death or OHT. **Methods:** We performed a retrospective review of fetal echocardiograms with diagnosis of HLHS from 10/2011 to 2/2017 combined with review of associated postnatal records. Study population was limited to fetuses with HLHS with intact ventricular septum. We excluded from our analysis fetuses who were electively terminated, who died in utero, who had planned postnatal non-intervention, or who had absent follow-up data. Presence or absence of CF was determined by review of serial fetal echocardiograms for each patient who met inclusion criteria. Survival analysis was used to evaluate the relationship between prenatal diagnosis of CF and freedom from transplant. **Results:** Of 89 patients with fetal HLHS, 10 had prenatal diagnosis of CF. Three (30%) of those with prenatally-diagnosed CF died and 4 (40%) required OHT. Of those without CF (n=79), 30 (38%) died and 8 (10%) underwent OHT. There was no difference in postnatal mortality in patients with and without CF (p=0.739). The patients with prenatal diagnosis of HLHS and CF had a significantly increased likelihood of OHT, p-value=0.001 (Figure 1). **Conclusion:** Prenatal diagnosis of CF in our cohort of patients with HLHS was associated with increased OHT but did not appear to be associated with increased postnatal mortality. These data have significance for prenatal counseling.



P1-68

Three-Dimensional Echocardiography Reveals Abnormal Tricuspid Septal Leaflet Coaptation with Normal Leaflet and Annular Dimensions after Repair of Tetralogy of Fallot

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Background: Tricuspid valve (TV) regurgitation is often seen in patients with repaired tetralogy of Fallot (TOF). We sought to characterize geometry, structure and function of TV annulus and leaflets in tetralogy of Fallot (TOF) in comparison with age and gender matched normal controls. **Methods:** Three-dimensional echocardiography (3DE) was prospectively performed using the iE33 system (Philips). Full-volume acquisitions of the TV and right ventricle (RV) were performed from an RV-focused apical view using ECG gating over 2-5 consecutive cardiac cycles. Annular [area, perimeter, circularity, dimensions at late diastole, inter-commissural distances in mid systole] and leaflet parameters [tenting height, tenting volume, area (anterior, posterior, septal, total), coaptation distances (anteroseptal, posteroseptal, anteroposterior)] were measured

using custom software. **Results:** The cohort consisted of 40 TOF subjects (17/23 female/male, age 14.7±9.8 years, body surface area (BSA) 1.3±0.5 m^2), and 40 age and gender matched controls (age 14.8±9.8 years, BSA 1.4±0.6 m^2). The annular parameters in TOF were not significantly different from controls (TOF vs. controls: annulus area 6.5±3.7 vs.7.7 ±3.9 cm^2, perimeter: 8.9±2.8 vs. 9.8±2.5 cm, longest axis length: 3.1±1.0 vs. 3.4±0.8 cm, shortest axis length: 2.5±0.9 vs. 2.8±0.9 cm). Among the leaflet parameters, the anterior-septal and posterior-septal coaptation distances were smaller in TOF (TOF vs. controls: 17.8±5.7 vs. 22.5±6.5 mm, 16.7±5.6 vs. 22.2±6.0 mm, all p<0.001) whereas the individual and total leaflet areas (anterior: 2.4±1.4 vs. 2.0±1.0 cm^2, posterior: 2.1±1.1 vs. 2.5±1.4 cm^2, septal: 2.8±1.8 vs. 2.8±1.5 cm^2, total: 7.7±4.0 vs.7.7 ±3.5 cm^2) were similar to controls. **Conclusion:** In this cohort of repaired TOF, the TV annulus was not dilated, and the leaflet sizes, tenting heights and tenting volumes were not abnormal. Septal leaflet coaptation distances with other leaflets were short. This may be attributed to anatomic changes related to the ventricular septal patch; further investigation is needed to determine the relation, if any, to tricuspid regurgitation.

P1-69

Right Ventricular Systolic Function in Patients with Hypoplastic Left Heart Syndrome Following Norwood Operation: A Novel Method Using Doppler dP/dT Across the Sano Shunt

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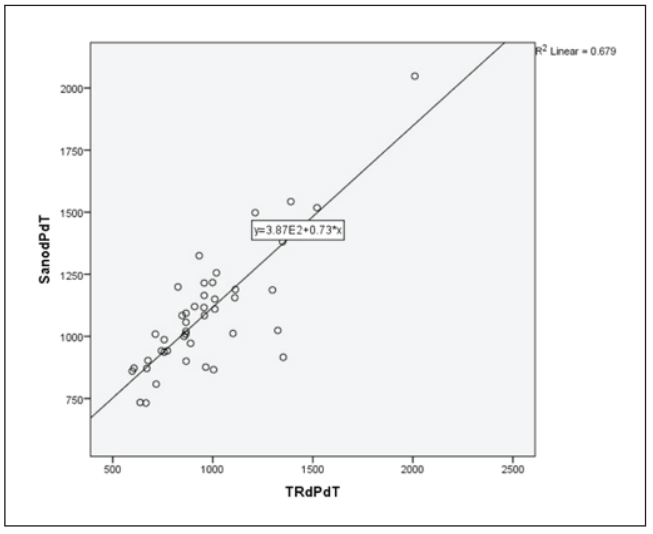
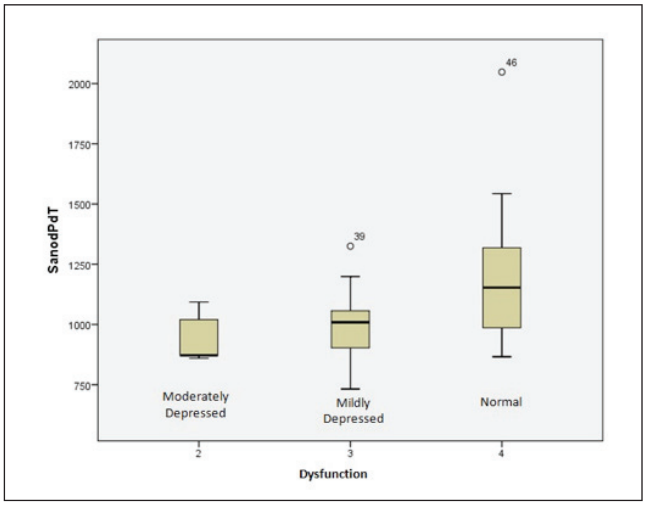
Background: Hypoplastic left heart syndrome (HLHS) is of the highest risk lesions in congenital heart disease. The initial surgery typically involves the Norwood procedure, frequently with Sano modification. Despite surgical advances, interstage mortality remains approximately 10%, with diminished right ventricular (RV) systolic function a risk factor for death. Tricuspid regurgitation (TR) derived dP/dT has been shown to correlate with catheter derived dP/dT in patients with HLHS, and is frequently used in assessment of RV systolic function. However, in patients without an adequate TR Doppler signal, this modality cannot be used. The purpose of this study was to evaluate the correlation between a Sano derived RV dP/dT and TR derived RV dP/dT in the assessment of RV systolic function following Norwood operation with Sano modification. **Methods:** An echocardiographic retrospective review was performed in patients following a Norwood/Sano operation, and assessed for the presence of a continuous wave Doppler tracing across the tricuspid valve and Sano shunt. 46 studies met this criteria. A dP/dT for both methods was measured between 1 and 3 m/s, and a qualitative assessment of function was also assigned to each study. **Results:** The mean value of TR derived dP/dT and Sano derived dP/dT was 979.9 mmHg/s and 1102.89 mmHg/s respectively. A linear relationship exists between a Sano and TR derived RV dP/dT, where the TR derived RV dP/dT = 387+0.73x, (p=0.001). There was also a statistically significant relationship between the Sano derived dP/dT and the qualitative analysis of RV systolic function, particularly in the higher values. Moderately diminished function was found to have a Sano derived dP/dT of 860 to 1093, mildly diminished 732 to 1325, and normal function 866 to 2048. **Conclusions:** Sano derived RV dP/dT can be effectively used as a surrogate for TR derived RV dP/dT, which may be of use in patients with inadequate TR. There is a statistically significant correlation between the Sano dP/dT and the qualitative assessment of function.





P1-70

Right Ventricular Failure in Fontan Patients with Systemic Right Ventricle: A Failure of Adaptive Remodeling, an Echocardiographic Study

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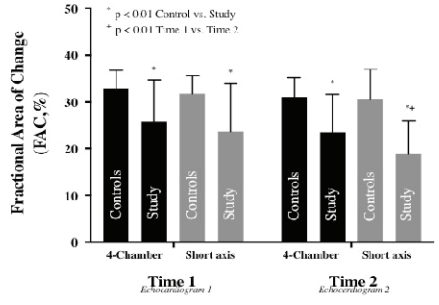
Background: Survival rates for Fontan patients with a systemic right ventricle (RV) have improved, but the RV often fails requiring heart transplantation. Intrinsic RV myocardial architecture and pump function mechanism may be substrates for failure. We hypothesize that failure of adaptive ventricular remodeling of systemic ventricle after Fontan palliation leads to RV failure. **Methods:** In a retrospective longitudinal study of 52 patients status post extracardiac Fontan for univentricular heart of RV morphology, echo measures of RV longitudinal shortening [tricuspid annular plane systolic excursion (TAPSE), fractional area of change (FAC) in 4-chamber view], circumferential shortening (FAC in short axis view), and RV-vascular coupling [neo-aortic pre-ejection time (PET), ejection time (ET), PET/ET, acceleration time/ET] were compared between patients who received heart transplant for RV failure, and without Fontan failure (control group, n=26) at two time points, *Time 1*: day of listing for transplant and *Time 2*: 1-3 months prior to transplant in the study group, with the corresponding time from Fontan in the control. Patients were matched for age, body surface area and cardiac lesion. **Results:** Mean time difference between Time 1 and Time 2 was 1.4 years. TAPSE was similar between groups at Time 1, but increased within the control at Time 2 (p<0.05). Longitudinal and circumferential shortening by FAC were significantly (p<0.01) higher in the control compared to the study group at both time points (Figure). Circumferential shortening mimicking left ventricle continued to increase in the control between time points, whereas it worsened in the study group (p<0.01). Neo-aortic ratios of PET/ET and acceleration time/ET were similar between groups at both time points but velocity time integral was significantly (p =0.01) higher in the control than the study group at both times (Table). **Conclusion:** Failure of adaptive remodeling of the RV after Fontan for univentricular heart contributed to end stage RV failure. Development of enhanced circumferential shortening, mimicking the left ventricle, appears to be an adaptive preventive mechanism for heart failure. Echo changes in longitudinal and circumferential shortening, and velocity time integral may predict progressive RV failure after extracardiac Fontan.

Poster Session 1 (P1)

Sunday, June 24, 2018

Figure: Progression of fractional area of change (longitudinal and circumferential)



Time 1: time at transplant listing in the study group and the corresponding time span from the Fontan in the control and
Time 2: 1-3 months prior to transplant in the study group and the equivalent time span from Fontan in the control.

Table: Comparison of clinical and echocardiographic data between controls and study patients

	Time # 1			Time # 2		
	Control (n=26)	Study (n=26)	P-value	Contro (n=26)	Study (n=26)	P-value
Age of Fontan (years)	5.6 (3.4 - 5.0)	4.1 (3.6 - 5.8)	0.06	5.6 (3.4 - 5.0)	5.1 (3.6 - 5.8)	0.06
Age at echocardiogram (years)	6.2 (5.2 - 7.9)	7.8 (6.5 - 12.5)	0.19	7.8 (4.6 - 14.8)	9.0 (5.6 - 16.4)	0.88
Years after Fontan	3.2 (0.8 - 5.6)	3.5 (0.4 - 7.4)	0.65	4.8 (1.2 - 12.8)	4.7 (1.0 - 13.4)	0.64
Age of Transplant (years)	NA	8.7 (5.3 - 16.1)		NA	8.7 (5.3 - 16.1)	
Body surface area (m^2)	0.9 (0.7 - 1.0)	0.8 (0.7 - 1.1)	0.95	1.0 (0.7 - 1.5)	1.0 (0.7 - 1.4)	0.73
Heart Rate (bpm)	77 (66 - 98)	105 (87 - 118)	0.11	76 (71 - 94)	98 (85 - 118)	0.01
SBP (mmHg)	104 (100 - 110)	95 (91 - 105)	0.12	99 (90 - 114)	99 (86 - 108)	0.36
DBP (mmHg)	52 (51 - 63)	56 (54 - 59)	0.60	60 (54 - 99)	59 (51 - 67)	0.77
Right ventricular function						
TA^SE (cm)	0.9 (0.7 - 1.0)	0.8 (0.6 - 0.99)	0.37	1.0 (0.8 - 1.1)	0.8 (0.7 - 1.0)	0.01
Fractional area of change (%)						
Four chamber	32 (31 - 35)	24 (19 - 32)	0.02	31 (30 - 33)	22 (18 - 31)	< 0.001
Short axis	31 (30 - 34)	29 (18 - 35)	0.01	30 (28 - 35)	19 (12 - 22) *	< 0.001
Non-aortic dimensions						
Pre-ejection time (PET, ms)	105 (76 - 124)	108 (95-128)	0.70	124 (105 - 143) *	105 (89 - 133)	0.25
Ejection time (ET, ms)	252 (231 - 275)	240 (210 - 275)	0.67	244 (226 - 277)	207 (196 - 263)	0.02
Acceleration time (AT, ms)	110 (101 - 113)	101 (88 - 127)	0.61	104 (97 - 110)	101 (85 - 117)	0.25
PET/ ET	0.44 (0.38 - 0.48)	0.48 (0.31 - 0.55)	0.31	0.49 (0.41 - 0.57)	0.48 (0.4 - 0.65)	0.59
AT/ET	0.42 (0.38 - 0.48)	0.44 (0.34 - 0.51)	0.69	0.42 (0.40 - 0.47)	0.45 (0.42 - 0.48)	0.48
Aortic Dia (mm)	2.0 (1.9-2.1)	2.0 (1.9 - 2.3)	0.53	2.0 (1.8 - 2.2)	2.0 (1.8 -2.2)	0.82
Aortic CSA (cm^2)	3.1 (2.9 - 3.5)	3.1 (2.9 - 4.2)	0.42	3.1 (2.5 - 3.8)	3.1 (2.5 - 3.8)	0.72
Aortic VTI mean (ms)	18 (14.9 - 21.3)	14.6 (13.0 - 16.0)	0.01	17.4 (14.8 - 20.0)	14.9 (12.0 - 16.3)	0.01
Aortic SV (ml)	54.4 (48.0 - 65.8)	48.2 (42.6 - 59.5)	0.17	53.0 (39.7 - 68.4)	42.3 (34.8 - 53.7)	0.07
Hemodynamics						
CO (L/min)	4.3 (4.1 - 4.8)	4.5 (4.1 - 5.2)	0.70	4.2 (3.3 - 5.1)	4.4 (3.5 - 5.4)	0.7
CI (CO/BSA, L/min/m2)	5.6 (4.2 - 5.7)	4.9 (4.3 - 6.3)	0.82	3.9 (3.3 - 5.4) *	4.2 (3.1 - 5.3)	0.86
Compliance (SV/PP, ml/mmHg)	1.3 (0.9 - 1.4)	1.2 (1.1 - 1.3)	0.61	1.4 (0.9 - 1.8)	1.1 (0.9 - 1.4)	0.13
Work (SV x PP, ml*mmHg)	2096 (1532 - 4250)	3374 (3079 - 3895)	0.29	3713 (2383 - 5881)	3200 (2675 - 4200)	0.18

All data presented as median (IQR); P-value, unpaired t-test, contro vs. transplanted patient; * P < 0.01 compared to Echo # 1, paired t-test
Control, non failed Fontan patients with anatomical RV for their systemic ventricle
Study, failed Fontan patients with anatomical RV for their systemic ventricle who received heart transplantation

P1-71

Bridging the Gap - Creation of a Third Trimester Fetal Cardiac Z-Score System

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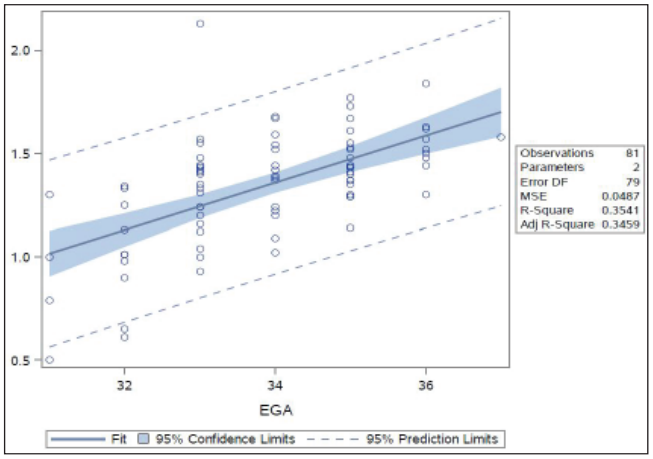
Background: Fetal cardiac Z score systems are predominantly derived from second trimester and early third trimester fetuses. Due to hemodynamic changes late in pregnancy, extrapolation of such data may not be appropriate for interpreting cardiac structures throughout third trimester. This is especially vital when assessing ventricular discrepancy and other secondary changes to rule out coarctation of aorta. Therefore, the aim of this study was to develop a Z score system specifically geared towards third trimester fetuses. **Methods:** 102 normal healthy females with singleton fetuses of gestational age ranging from 31-37 weeks were included in the study. Standard fetal cardiac dimensions, aortic and pulmonary valve velocities were measured on their fetal echocardiogram. Linear regression analyses was performed in relation to femur length (FL) and gestational age (GA). **Results:** P values were <0.001 with R^2 ranging from 0.17-0.38 for cardiac dimensions with significant relationship with GA and FL. Normative equations with Z scores were calculated for these variables. Figure 1 shows a fit plot for the cardiac dimension measuring right ventricular end diastolic dimension (RVEDD). Similar plots with Z scores were calculated for other dimensions of significance. **Conclusions:** In response to obstetrical practice guidelines that support routine third trimester ultrasound, these results provide robust normative data for fetal cardiac structures late in pregnancy. Therefore this study's findings will aid in important clinical decision making that is required shortly before delivery.



P1-72

Echocardiographic Predictors of Primary Common Atrioventricular Canal Repair Timing and Outcomes

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Background: In complete atrioventricular canal defect (CAVC), there are limited data on pre-operative echocardiographic predictors of operative timing and post-operative outcomes. **Methods:** A retrospective, single center analysis of all patients who underwent primary biventricular repair of CAVC between 2006 and 2015 was performed. Associated cardiac anomalies (tetralogy of Fallot, double outlet right ventricle) or need for neonatal arch repair were excluded. Echocardiographic findings on first postnatal echocardiogram were correlated with surgical timing and post-operative outcomes using univariate and multivariate logistic regression adjusting for clinical factors, including Down's syndrome, prematurity < 37 weeks, birth weight, pre-operative pulmonary hypertension, feeding fortification, supplemental oxygen, and weight at surgery. **Results:** 153 subjects (40% male, 84% Down's) underwent primary CAVC repair at a mean age of 102 days (range 25-217). Eight patients (5%) died post-operatively and 24 (16%) required re-operation within 1 year. On multivariate analysis, isthmus z-score less than -2 was associated with primary repair before 3 months (OR 2.8, 95% CI 1.2-6.2; p=0.013), need for re-operation within 1 year (OR 4.0, 95% CI 1.3-12.9; p=0.019), and mortality (OR 37.9, 95% CI 1.2-1197.1; p=0.039). Pre-operative ventricular dysfunction was likewise associated with mortality (OR 51.6, 95% CI 1.9-1428.6; p=0.020) and also with post-operative utilization of extracorporeal membrane oxygenation (ECMO) (OR 31.5, 95% CI 3.3-298.7; p=0.003). There was a trend toward an association between isthmus z-score less than -2 and post-operative length of stay over 7 days (OR 2.2, 95% CI 0.9-5.0; p=0.068). Notably, pre-operative atrioventricular valve regurgitation was not associated with surgical timing, post-operative outcomes or re-operation, and there were no echocardiographic predictors of late re-operation beyond one year after repair. **Conclusion:** Key pre-operative echocardiographic parameters help predict operative timing and post-operative outcomes in infants undergoing primary CAVC repair. Aortic isthmus z-score less than -2 was associated with early surgical repair, increased mortality and need for re-operation, while pre-operative ventricular dysfunction was associated with increased mortality and need for ECMO support. These echocardiographic findings are helpful for risk-stratifying patients undergoing CAVC repair.

P1-73

Echocardiographic Findings After Left Pulmonary Artery Sling Repair

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Background: Left pulmonary artery (LPA) sling is a rare congenital heart defect that uniformly requires surgical intervention. While operative results have been excellent, some degree of residual LPA stenosis is expected. Currently, there is variability in indications for and rates of re-intervention for these patients across institutions. **Methods:** We performed a retrospective chart review of patients who underwent LPA sling repair at our institution. When available, echocardiographic data was collected for patients during the pre-operative, immediate post-operative, 6 month, 1 year, 2 year, and >2 year post-operative periods. Nuclear medicine perfusion data was reviewed to assess differential pulmonary blood flow post-operatively. Results were analyzed using linear mixed effects modeling. **Results:** A total of 18 patients were included in the review. All patients had at least one post-operative echocardiogram and nuclear medicine perfusion study. The LPA size, derived from 2-D echocardiographic images significantly decreased

from pre-operative (z-score -0.5 ± 1.6), to the immediate post-operative (z-score -1.9 ± 1.3), and during long term follow-up at > 2 years (z-score -3.4 ± 0.3) (p-value= 0.0012). There was no significant change in the LPA peak velocity from pre-operative (2.1 ± 0.5 m/s) to the immediate post-operative (2.4 ± 0.8 m/s), or during long-term follow-up at >2 years (2.4 ± 0.5 m/s) (p-value= 0.155). Immediately post-operatively there was mildly unbalanced blood flow to the right lung compared to the left (65.7 ± 11.1% versus 34.3 ± 11.1% respectively), which stabilized at 6 months follow-up (59.5 ± 3.5% to the right vs. 40.5 ± 3.5% to the left). Only one of the patients underwent re-intervention secondary to severely unbalanced pulmonary blood flow. **Conclusions:** In pediatric patients undergoing LPA sling repair, post-operatively the proximal LPA demonstrates a significant decrease in size that tends to persist and worsen with time, with no change in the peak velocity in this vessel. While lung perfusion is initially mildly unbalanced, it stabilizes over follow-up and very rarely requires re-intervention. These results suggest that some degree of post-operative LPA hypoplasia can be expected, and a conservative approach to re-intervention is acceptable given excellent long term results.

Timepoint	LPA size by z-score	Peak Velocity (m/s)
	Mean ± SD	Mean ± SD
Immediate Pre-op	-0.5 ± 1.6	2.1 ± 0.5
Immediate Post-op	-1.9 ± 1.3	2.4 ± 0.8
6 mo Post-op	-1.9 ± 1	2.6 ± 0.8
12 mo Post-op	-2.6 ± 0.8	2.5 ± 0.9
2 yr Post-op	-2.8 ± 0.8	2.7 ± 1.1
>2 yr Post-op	-3.4 ± 0.3	2.4 ± 0.5

Table 1. Echocardiographic LPA size and peak velocity over time in patients with repaired LPA sling over time

P1-74

Atrial Mechanics and Atrio-Ventricular Interaction in Single Ventricle Patients

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Background: Previous studies have shown that single right ventricles (SRV) have worse systolic and diastolic function compared to single left ventricles (SLV) after the Fontan procedure. Atrial strain has shown promise in evaluating diastolic dysfunction and cardiac magnetic resonance imaging (CMRI) remains the gold standard in evaluating ventricular function. Atrio-ventricular interaction in single ventricles has not been evaluated. In this study, we evaluated atrial function using speckle tracking echocardiography and correlated with CMRI ventricular function and exercise performance in Fontan patients. We hypothesized that SRV will have worse atrial function and exercise capacity compared to SLV. **Methods:** Twenty-three patients with single ventricle physiology status post Fontan procedure were evaluated with CMRI, exercise stress test and atrial strain analysis (TomTec 2D-CPA). CMRI, exercise stress test, and echocardiograms were obtained within 2 months of each other. Strain analysis evaluated the dominant atrial strain, strain rate, max and minimum volumes and atrial emptying fraction (AEF). MRI data evaluated end systolic volume indexed (ESVi), stroke volume (SV), ejection fraction (EF), indexed ventricular mass and cardiac output (CO). Atrial deformation, exercise stress testing and MRI hemodynamics were compared using Student's *t*-test and linear regression model was applied to assess correlations between atrial and ventricular metrics. **Results:** Eight SRV patients (age 10-23 yo) were compared to 15 SLV patients (age 10-18 yo). There was no difference found between atrial strain in SRV and SLV patients. In addition, there was no difference in exercise metrics, ESVi, SV, CO or ventricular mass (Table 1). There was a significant decreased in RV EF compared to LV (57 vs 50, p-0.036). There was no correlation between the atrial and ventricular metrics. **Conclusion:** Atrial strain and exercise metrics between SRV and SLV patients showed no difference. SRV patients have worse ventricular function compared to SLV patients. The atrio-ventricular interaction remains unknown and requires further study.

Table 1. LV vs. RV Dominance

	Dominant LV (n = 15)	Dominant RV (n = 8)	P-Value
Exercise Data			
peak VO2	1.18 ± 0.35	1.14 ± 0.36	0.779
peak VO2i	29.0 ± 5.0	25.3 ± 6.7	0.192
O2 sat Rest	89 ± 4	91 ± 3	0.342
O2 sat Ex	84 ± 8	87 ± 4	0.333
RER	1.13 ± 0.13	1.08 ± 0.08	0.274
MRI Data			
ESVi	35 ± 8	39 ± 14	0.447
SV	56 ± 17	50 ± 19	0.485
EF	57 ± 8	50 ± 5	0.036
mass(i)	41 ± 9	39 ± 10	0.776
CO	4.9 ± 1.6	4.4 ± 1.9	0.589
Atrial Strain Data			
eS	30 ± 9	29 ± 8	0.772
eE	18 ± 6	18 ± 6	0.768
eA	12 ± 4	11 ± 4	0.484
SRS	1.0 ± 0.7	1.0 ± 0.3	0.787
SRE	-1.3 ± 0.3	-1.3 ± 0.7	0.87
SRA	-1.1 ± 0.7	-0.9 ± 0.5	0.489
max Vol	28 ± 10	35 ± 19	0.382
min Vol	13 ± 5	18 ± 14	0.355
AEF	53 ± 10	49 ± 12	0.449
HR	72 ± 14	81 ± 17	0.227
Doppler E'	0.65 ± 0.12	0.89 ± 0.35	0.099
Doppler A'	0.47 ± 0.12	0.56 ± 0.23	0.319

Ex- exercise, ESVi- end systolic volume indeed, SV- stroke volume, EF- ejection fraction, CO- cardiac output, eS- peak atrial strain, eE- conduit strain, eA- active atrial pump strain, SRS- Strain rate S', SRE- Strain rate E', SRA- Strain rate A', AEF- Atrial emptying fraction, HR- heart rate

P1-75

Prenatal Identification of Atrioventricular Septal Defect and Associated Genomic Abnormality by Fetal Echocardiography and Whole Genome Sequencing

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Objective: We sought to correlate fetal echoardiographic characteristics of atrioventricular septal defect (AVSD) with genomic abnormalities using whole genome sequencing (WGS) and whole exomal sequencing (WES). **Methods:** We retrospectively reviewed 21179 fetal echocardiograms from September 2010 to June 2016 in our institution. A total of 150 fetuses were diagnosed as AVSD, in which 47 cases had termination of pregnancies by parental choices and fetal umbilical cord and their parental peripheral blood were obtained and WGS and WES performed. **Results:** For the 47 fetuses with AVSD with both fetal echocardiographic and genomic data, the mean gestation age was 25±5.9 weeks (range 16-37 weeks). In this group, 38 fetuses had complete AVSD (80.9%), 7 partial AVSD (14.9%), and 2 transitional AVSD (4.26%). Among the 38 fetuses with complete AVSD, 10 had unbalanced AVSD (26.3%), and 28 balanced AVSD (73.7%). In addition, 27 fetuses (27/47, 57.4%) had associated intracardiac defects, including 23 (23/27,85.2%) had conotruncal defect, 2 anomalous pulmonary venous connection, and 2 aortic coarctation. There were 19 fetuses (19/47,40.43%) with associated extra-cardiac anomalies: 18 in complete AVSD and 1 in partial AVSD, whereas 14 associated with both other intra-cardiac and extra-cardiac anomalies. In 47 fetuses with AVSD, DNA was extracted successfully in 43 fetuses, but failed in 4 because of tissue degradation. Genomic studies showed positive results in 22 fetuses (51.2%), including trisomy 21 (n=11), trisomy 18 (n= 2), trisomy 13 (n=1), large chromosome duplication (n=2) and single-gene mutation (n=6). There were 7 positive genomic studies in 27 AVSD associated with other intra-cardiac anomalies (25.9%), 14 in 19 AVSD associated with extra-cardiac anomalies (73.7%) and 11 in 14 AVSD associated with intra-cardiac and extra-cardiac anomalies (78.6%). **Conclusion:** Fetal AVSD has a high association with extra- and intra-cardiac anomalies, especially in complete AVSD; and a high association with genomic abnormalities. Genetic testing, which may include WGS and WES, may be considered after prenatal diagnosis of AVSD by fetal echocardiography.

P1-76

Single Left Ventricular Diastolic Function After Fontan: A Distinct Phenotype Compared to Age-Matched Controls

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Background: Children with single left ventricles (SLV) after Fontan have abnormal diastolic function. The mechanistic patterns as they relate to SLV subtypes are poorly understood. The aims of this study were to: compare diastolic function between SLV and age-matched controls; compare SLV subtypes, including tricuspid atresia, pulmonary atresia with intact ventricular septum, and double-inlet LV; correlations between echocardiographic measures of diastolic function and ejection fraction (EF) were evaluated. We hypothesized that SLV would manifest a distinct diastolic phenotype,

and that diastolic function would correlate with EF. **Methods:** Multi-center, prospective, observational cohort study. Fifty-two children with single LV after Fontan operation and age-matched controls were enrolled. Echocardiographic measurements were obtained according to published guidelines, including mitral inflow velocities, tissue Doppler, and parameters related to timing of events in the cardiac cycle. Statistics included t-tests and Pearson's correlation. **Results:** Compared to age matched controls, SLV had decreased peak E wave velocities, with decreased E/A ratio (Table). Similarly, e' was decreased in the SV cohort. E/e' was significantly decreased at the lateral wall. IVRT was prolonged; the myocardial performance index (MPI) was abnormal, driven by abnormalities in IVRT. No differences were found between single LV subtypes. There were no significant correlations between diastolic parameters and EF. **Conclusion:** Children with SLV after Fontan operation have a distinct diastolic phenotype compared to controls, manifesting as decreased E wave velocity and prolongation of IVRT. This diastolic phenotype reflects a lower early diastolic trans-mitral pressure gradient. The assessment of diastolic 'dysfunction' is confounded by the unique physiology of the Fontan circulation, a chronically preload-deficient state; in addition, factors such as a disadvantageous mass:volume, myocardial fibrosis, among others, also affect the rate of ventricular filling in early diastole. In conclusion, our cohort of SLV's, ideal, archetypal Fontans, a diastolic phenotype is present. Further characterization of factors contributing to this phenotype will require comparison to simultaneous, invasively-derived data.

Echocardiographic Measures of Diastolic Function in Single Left Ventricles vs. Age-Matched Controls

	Single LV	Controls		Single LV	
	Median (IQR) Or Mean (SD)	Median (IQR) Or Mean (SD)	p-value	Pearson's Correlation with EF (R)	*p*-value
	n = 52	n = 52			
LV Length (cm)	5.57 (0.86)	6.71 (1.02)	**<0.0001**	-0.17	0.25
M-mode Measurements					
LV End-Diastolic Diameter (cm)	4.4 (1.1)	4.3 (0.7)	0.2	-0.22	0.12
LV End-Systolic Diameter (cm)	2.9 (0.8)	2.7 (0.7)	**0.03**	-0.27	0.07
Mitral Inflow Doppler					
Left Ventricular Ejection Time (ms)	295.4 (50.7)	282 (41)	0.3		
Mitral Valve Filling Time (ms)	522.3 (176.1)	451.1 (157.7)	**0.03**	0.10	0.53
Mitral Valve Closure to Opening Time (ms)	400.6 (38.7)	363.8 (34.2)	**<0.0001**	-0.07	0.63
Mitral Valve Systolic:Diastolic Ratio	0.58 (0.28)	0.67 (0.29)	0.06	-0.04	0.77
Myocardial Performance Index (Blood pool)	0.376 (0.105)	0.287 (0.103)	**<0.0001**	-0.22	0.15
Mitral Inflow Peak E Wave (m/s)	0.67 (0.14)	0.91 (0.17)	**<0.0001**	0.02	0.9
Mitral Inflow Deceleration time (ms)	157.0 (23.6)	136.6 (45.2)	**0.01**	0.03	0.85
Mitral Inflow E Wave Duration (ms)	216.8 (49.7)	215.9 (208.5)	0.2	0.13	0.43
Mitral Inflow Peak A Wave (m/s)	0.46 (0.24)	0.41 (0.17)	0.2	0.09	0.55
Mitral Inflow A Wave Duration (ms)	129.9 (38.6)	109 (26)	**<0.0001**	0.11	0.48
Mitral Inflow E:A Ratio	1.52 (0.63)	2.19 (1.03)	**<0.0001**	0.03	0.83
Pulmonary Vein Doppler					
Pulmonary Vein Peak S Wave (m/s)	0.51 (0.31)	0.46 (0.12)	0.1	0.13	0.38
Pulmonary Vein Peak D Wave (m/s)	0.71 (0.21)	0.59 (0.18)	**<0.0001**	0.08	0.61
Pulmonary Vein Peak A Wave (m/s)	0.26 (0.14)	0.16 (0.06)	**<0.0001**	-0.08	0.58
Tissue Doppler					

P1-77

Fetal Echocardiographic Parameters and Postnatal Outcomes in Congenital Left-sided Heart Lesions: A 15-year Single Center Experience

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Background: The study aims were to evaluate fetal echocardiographic parameters associated with neonatal intervention and single ventricle palliation (SVP) in fetuses with suspected left-sided cardiac lesions and our institutional accuracy of predicting these outcomes. **Methods:** Initial fetal echocardiograms (1/2002-1/2017) interpreted by the contemporary fetal cardiologist as coarctation of the aorta (COA), left heart hypoplasia (LHH), hypoplastic left heart syndrome (HLHS), mitral valve hypoplasia ± stenosis, and aortic valve hypoplasia ± stenosis (AVS) were included. Neonatal intervention was defined as cardiac catheterization or surgery performed prior to hospital discharge. **Results:** The cohort comprised 68 fetuses with suspected left-sided lesions (COA n=15, LHH n=9, HLHS n=39, mitral valve hypoplasia n=1, and AS n=4). Sixty-five mothers changed delivery location after diagnosis, while three mothers were local. We accurately predicted the postnatal diagnosis in 61/68 (90%) cases and need for neonatal intervention in 67/68 (99%) cases; in 6/7 cases not requiring intervention, the fetal cardiologist had a low suspicion for neonatal intervention, and the neonate was observed without starting prostaglandin. Lower LV length z-score, aortic valve z-score, ascending aorta z-score, and great vessel ratio; left-to-right shunting at the foramen ovale; and retrograde flow in the aortic arch were associated with the need for neonatal intervention (p=0.004-0.04). Lower mitral valve z-score, LV length z-score, aortic valve z-score, ascending aorta z-score, great vessel ratio, and LV ejection fraction, as well as higher RV/LV length ratio z-score, left-to-right shunting at the foramen ovale, abnormal pulmonary vein Doppler, absence of prograde aortic flow, and retrograde flow in the aortic arch were associated with SVP (p<0.001-0.008). Neonates with genetic abnormalities were more likely to undergo biventricular repair (p=0.04). The strongest independent variable associated with SVP was RV/LV length ratio z-score (stepwise logistical regression, p=0.02); an RV/LV length ratio z-score >2.4 predicted SVP with a sensitivity of 76% and specificity of 100% (AUC 0.91, p<0.001). **Conclusion:** Prenatal LV length z-score, great vessel ratio, and retrograde flow in the aortic arch were most strongly associated with the need for neonatal intervention. A fetal RV/LV length ratio z-score of >2.4 may be a useful threshold for identifying fetuses with the need for SVP and may be helpful for counseling expectant families.

P1-78

Diagnostic Value of Echocardiography Speckle Tracking and Magnetic Resonance Feature Tracking in Children with Myocarditis

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Introduction: Myocarditis is an important cause of morbidity and mortality in children. Myocardial strain has been shown to be a sensitive measure for myocardial function, including sub-clinical changes. We sought to compare the diagnostic value of echocardiography (echo) speckle tracking (ST) and cardiac magnetic resonance (CMR) feature tracking (FT) indices in children diagnosed with myocarditis. **Methods:** All patients diagnosed with myocarditis between 2014 and 2016 who had an echo and a CMR ≤5 days apart were included. Demographic and imaging characteristics were reviewed. Maximum troponin and BNP levels during the course of hospitalization were extracted. Late Gadolinium enhancement (LGE) burden was quantified (mild<25%, 25≤moderate<50%, severe≥50%) from CMR. FT and ST analyses were performed in short axis and 4-chamber views to calculate global circumferential (GCS), radial (GRS) and longitudinal (GLS) strain of the left ventricle. **Results:** Eighteen patients (Male=14) with a median age of 15.5 years (range: 8.4-17.7) met inclusion criteria. There was a median of 1 day (0-4) between echo and CMR. LGE was positive in 13 patients with median burden of 23% (0-75%). Functional characteristics are summarized in table 1. Left ventricular ejection fraction and GLS were not statistically different between echo and CMR (P=0.91 and 0.44), whereas GCS and GRS showed a significant difference (both P=0.02). Ejection fraction showed stronger correlation with GCS for both modalities. Unlike GLS, echo GCS (P=0.01) and GRS (P=0.03) and CMR GCS (P=0.03) and GRS (P=0.02) showed significant differences between patients with preserved and reduced ejection fraction. Correlation between CMR-GLS and LGE level was the strongest between functional indices and LGE, maximum troponin or BNP levels. **Conclusion:** Retrospective myocardial strain analysis using both ST and FT in children with myocarditis is feasible. GCS had the best correlation with ejection fraction for both modalities and GLS was the only index to not show significant differences between preserved and reduced ejection fraction groups. CMR-GLS showed the strongest correlation with LGE burden compared to other functional indices and biomarkers. These findings may suggest the sequence in which strain indices change in this patient population.

Table 1. Functional characteristics of the study population. Functional indices compared between CMR and echo (orange). Correlation of strain indices with corresponding LV EF (green), maximum TP level (yellow), maximum BNP level (red) and LGE burden (blue). BNP: Brain natriuretic peptide, N: count, STE: Standard error, TP: Troponin, WSR: Wilcoxon sign rank test.

			Ejection Fraction		Normal vs Reduced EF	Max Troponin		Max BNP		LGE burden	
		(WSR)	Linear Regression		Mann-Whitney	Linear Regression		Linear Regression		Multinomial Regression	
Functional analysis	Median (range)	P-Value	R^2, STE	P-Value	P-Value	R^2, STE	P-Value	R^2, STE	P-Value	pseudo-R^2	P-Value
Echo-GCS	20% (3-34%)	**0.02**	58, .4	<.005	**0.01**	.05, .5	0.37	.15, .45	0.13	0.06	0.64
CMR-GCS	16.6% (2-21%)		.81, .3	<.005	**0.03**	.15, .7	0.11	.01, .73	0.68	0.12	0.38
Echo-GRS	22.7% (0.3-60%)	**0.02**	.24, .2	0.04	**0.03**	.10, .2	0.21	.06, .22	0.37	0.13	0.36
CMR-GRS	33.2% (6-45%)		.73, .2	<.005	**0.02**	.14, .3	0.12	.01, .33	0.68	0.17	0.25
Echo-GLS	18.1 (5-29%)	0.44	.26, .6	0.03	0.11	.27, .5	**0.03**	.13, .54	0.16	0.10	0.46
CMR-GLS	17.8% (6-40%)		.36, .4	0.009	0.07	.18, .4	0.08	.01, .46	0.67	0.43	**0.02**
Echo-LVEF	57% (10-73%)	0.91				.25, .2	**0.04**	.14, .20	0.14	0.22	0.16
CMR-LVEF	54% (12-68%)					.21, .2	0.06	.07, .25	0.3	0.22	0.15

Poster Session 1 (P1)

Sunday, June 24, 2018

P1-79

Echocardiographic Nomograms of Right Ventricular Function in Pediatric Patients after Heart Transplantation

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Background: Assessment of cardiac function is an important component of follow-up after pediatric heart transplantation. While quantitative metrics of left ventricular function are well-established, normal values for right ventricular (RV) function are incomplete; in normal children, they exist only for some metrics, and they do not exist at all for certain populations, such as patients after heart transplantation. We thus created nomograms for RV function in normal children and in healthy heart transplant recipients. **Methods:** We retrospectively measured standard metrics of RV function by echocardiography in normal children and healthy pediatric heart transplant patients at our institution from 1/1/06 to 11/17/16. We selected the first echocardiogram (echo) that was at least 6 months from transplant and one year from clinically-apparent or biopsy-proven rejection. No echoes were used after the diagnosis of coronary graft vasculopathy or retransplant. Tricuspid annular plane systolic excursion (TAPSE), fractional area change (FAC), and peak tricuspid annular systolic tissue velocity (S') were measured offline using standard techniques. **Results:** 380 controls and 127 transplant patients were analyzed (Table). TAPSE values in controls were similar to published norms (Fig 1A). Transplant patients had TAPSE values significantly lower than controls (our cohort and published values) for all age groups ($p<0.0001$, Fig 1A). Transplant patients also had values for FAC and S' significantly below controls ($p<0.0001$ for both, Fig 1B-C); however, the majority of transplant FAC values remained within two standard deviations of the normal mean. **Conclusion:** We first present new normal values for metrics of RV function in healthy controls. TAPSE, FAC, and S' in seemingly healthy pediatric heart transplant recipients are significantly lower than these control values. However, FAC is relatively preserved compared to TAPSE and S', and may be a more useful parameter with which to assess RV function in this population.

Table. Demographic information for control and transplant subjects

	Controls (N=380)	Transplants (N=127)
Gender	216 male (57%); 164 female (43%)	67 male (53%); 60 female (47%)
Age at Transplant	N/A	Median: 5.8 years; IQR: 0.6-13.5 years
Age at Echo	Median: 10.4 years; IQR: 3.0-14.5 years	Median: 9.3 years; IQR: 3.1-15.0 years
Time from Transplant to Echo	N/A	Median: 1.2 years; IQR: 0.6-2.8 years

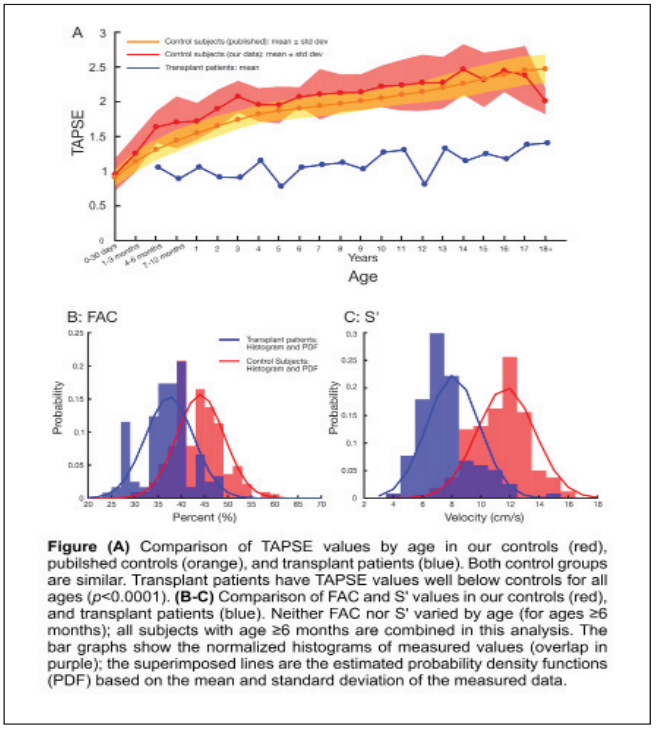

Figure (A) Comparison of TAPSE values by age in our controls (red), pubilshed controls (orange), and transplant patients (blue). Both control groups are similar. Transplant patients have TAPSE values well below controls for all ages ($p<0.0001$). **(B-C)** Comparison of FAC and S' values in our controls (red), and transplant patients (blue). Neither FAC nor S' varied by age (for ages ≥6 months); all subjects with age ≥6 months are combined in this analysis. The bar graphs show the normalized histograms of measured values (overlap in purple); the superimposed lines are the estimated probability density functions (PDF) based on the mean and standard deviation of the measured data.

P1-80

Single Site Pacing Location Significance in Pediatric Patients with Structural Congenital Heart Disease

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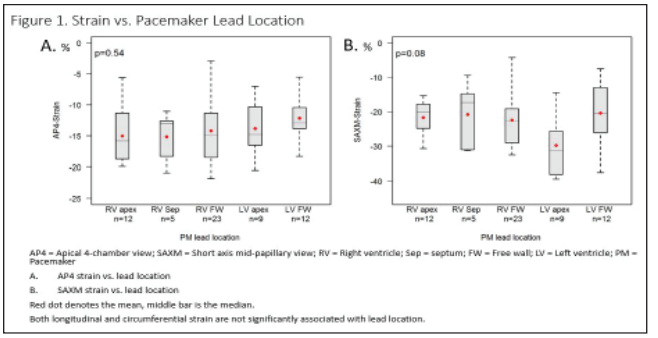
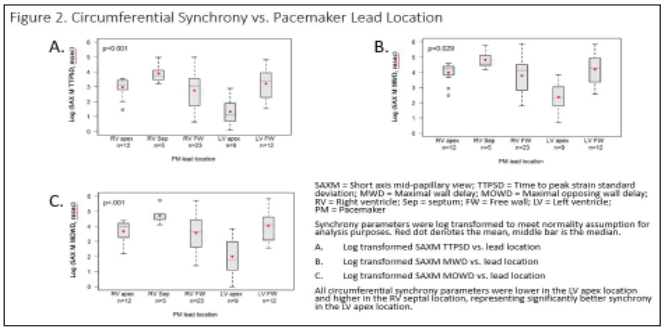
Background: Permanent pacing may have negative effects on ventricular function, with some adult evidence suggesting an impact of lead location on this decline; however, data from children with congenital heart disease (CHD) are scarce. We aimed to assess the association of lead location with ventricular strain and synchrony in a cohort of children with repaired CHD. **Methods:** Included patients were <21y old, with: a single site pacemaker (PM), biventricular circulation with a systemic LV, and echo images suitable for analysis by speckle-tracking strain after PM placement. Retrospectively-collected data included CHD type and 5 lead locations. Lead location was determined by surgical notes and chest X-ray. QLAB 10.8 was used to measure apical 4-chamber longitudinal strain (LS), short axis mid-papillary circumferential strain (CS) and synchrony parameters including time to peak strain standard deviation, maximal wall delay, and maximal opposing wall delay. Synchrony parameters were log transformed to meet normality assumption for analysis. Multivariable modeling included adjustment for time since lead placement. **Results:** n=67 echocardiograms on 55 patients were included (42% were male, mean age 8.2±6.3y, age range 2m-20.5y); 12 patients had 2 separate pacing sites. LV apical leads had a shorter time interval from lead placement compared to other locations (median 3.5 months vs. ≥30 months, p=0.008). LS did not vary among lead locations (p=0.56); nor did CS (p=0.15; Figure 1). Circumferential synchrony was better with an LV apical lead and worst with an RV septal lead ($p<0.001$; Figure 2), while longitudinal synchrony was similar among lead locations. **Conclusion:** Ventricular lead placement is related to circumferential synchrony of the LV; no association of lead location was present, however, with longitudinal synchrony or any strain component. These findings support a potential impact of lead placement on ventricular conduction patterns, and suggest the need for further study.





P1-81

Single Left Ventricular Function Following Fontan Palliation In Pulmonary Atresia Vs. Tricuspid Atresia: A Speckle Tracking Echocardiographic Study

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Background: Single left ventricular dysfunction after Fontan palliation remains a leading cause of long-term mortality. There is paucity of data on single left ventricular function using speckle tracking echocardiography. Neonates with pulmonary atresia and intact ventricle septum (PA/IVS) often have coronary abnormalities, which could further increase the risk for ventricular dysfunction. We hypothesized that single left ventricular function following Fontan palliation will be impaired on speckle tracking echocardiography and worse in PA/IVS compared to Tricuspid atresia. **Methods:** This observational study included patients with single left ventricular physiology (PA/IVS and Tricuspid atresia), who underwent Fontan palliation > 1 year ago. Global systolic

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endocardial and myocardial longitudinal strain (GLSendo, GLSmyo) and average of peak longitudinal strain of 6 segments (peakLendo and peakLmyo) from the apical 4 chamber view were analyzed offline using vendor-independent software (Tomtec. Inc) by a single reader. Myocardial performance index, ratio of early and late mitral valve inflow velocities on spectral Doppler and E/e‘ ratio on tissue Doppler of the septal and lateral annulus of the mitral valve were calculated. The 2 study groups were compared using t-test and Chi square test. **Results:** Study cohort (n=78) included 30 patients with PA/IVS. Myocardial performance index, GLSendo and GLSmyo and peakLendo and peakLmyo measures were abnormal. The two groups (PA/IVS vs. tricuspid atresia) were similar in age and gender distribution. Speckle tracking echocardiographic measures were comparable between the two groups, with no significant differences in the GLSendo, GLSmyo, PeakLendo and PeakLmyo. Other conventional echo parameters of diastolic and global function were also comparable in the two groups. **Conclusion:** Global longitudinal strain, peak longitudinal strain and myocardial performance index were abnormal in patients with single left ventricle physiology after Fontan palliation. There were no differences in conventional or speckle echocardiographic measures between the PA/IVS and tricuspid atresia groups, suggesting PA/IVS is not at higher risk for single ventricle dysfunction. Fontan palliation may be an acceptable therapeutic option for both conditions.

Table: Comparison of the demographic and echocardiographic parameters

Parameter (mean±SD) or n%	PA/IVS (n=30)	Tricuspid atresia (n=48)	p value
Age at echo (years)	16.8±10.3	19.3±10.8	0.31
Male (%)	12 (40%)	22 (45.8%)	0.32
Height (cm)	146±26.6	153±22.1	0.18
Weight (kgs)	51±29	55.9±24.2	0.42
Body Surface Area (m2)	1.38±0.5	1.53±0.48	0.18
Systolic Blood Pressure (mmHg)	112±18	115±18	0.5
Diastolic Blood Pressure (mHg)	61±9	63±10	0.5
Heart Rate	75±15	69±13	0.08
End Diastolic Volume (ml)	90.1±56.4	109.3±67	0.21
End Systolic Volume (ml)	45.4±33	59.5±44.1	0.15
Ejection Fraction %	51.5±12.7	47.9±11.3	0.22
Endo GLS %	-15.25±3.9	-15.93±4.7	0.52
Myo GLS %	-12.06±3.4	-12.4±4.1	0.67
Average Peak LS endo %	33.6±16.5	30.9±13.8	0.44
E/A ratio	1.41±0.53	1.51±0.54	0.39
MPI (spectral Doppler)	0.48± 0.14	0.47±0.14	0.7
E/e' ratio (septal)	14.43±4.9	14.28±7.85	0.93
MPI septal (Tissue Doppler)	0.72±0.21	0.70±0.17	0.70
E/e' ratio (lateral)	7.13±1.61	6.5±2.5	0.30
MPI lateral (Tissue Doppler)	0.56±0.18	0.5±0.22	0.35

P1-92 Moderated Poster

Do Patients with Hypermobile Ehlers-Danlos Syndrome and Normal Initial Echocardiograms Need Follow Up?

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Background: The hypermobile Ehlers-Danlos syndrome (hEDS) is a hereditary connective tissue disorder which can have aortic root dilation, mitral valve prolapse (MVP) and rarely aortic rupture. The current guidelines recommend initial screening echocardiogram for all hEDS patients and repeat imaging every other year for children and three to five years for adults. Previous studies with smaller sample sizes have shown varying results on aortic measurements and valvar pathology. As hEDS is a clinical diagnosis, there is a great need for a larger cohort of patients to be evaluated. Our aim was to investigate if there were any significant/abnormal aortic measurements and /or valve abnormalities in a large cohort and report natural history using echocardiography. **Methods:** We retrospectively reviewed 1060 patients from a single center, of whom 836 met the inclusion criteria. Based on these echocardiograms, we recorded measurements at the aortic annulus, aortic root, sinotubular junction and ascending aorta. Aortic and mitral valves were also evaluated. Both Devereux and Boston Z scores were used for the aortic measurements. **Results:** At diagnosis, the mean age was 20.5 years, a median Beighton score of 8. hEDS was higher among females 71.1%, and Caucasian 89.5%. The aortic measurements are listed in table 1. Out of 836, 9 had bicuspid aortic valves (1.07%), 9 had mild aortic regurgitation (1.07%), 24 had MVP (2.87%), 75 had mild mitral regurgitation (MR) (8.97%) and 3 had moderate MR (0.36%). **Conclusion:** This is the largest sample size based on the PubMed literature search, studying the relation between hEDS and the aorta, mitral and aortic valves. Based on our results, the findings of aortic root dilation is not statistically significant and there is no abnormal progression of the measurements on follow up. Based on the low prevalence of the aortic involvement and mitral valve abnormalities in the hEDS patients, we suggest that follow up of these patients with initial echo documenting normal measurements might not be needed. The exceptions include abnormal echocardiogram findings and/or if they are symptomatic.

Table 1: Evaluation of Aorta and measurements

Location	Total (n)1114	Devereux Z score >15 y/o	Boston Z score < 15 y/o
Aortic Root/Sinus Valsalva	1102	n= 611	n= 491
Z score range		-3.51 to +2.97	- 2.14 to +4.46
Z score > +2		12 (2%)	25 (5.1%)
		Boston Z Score (no age restriction)	
Aorta Annulus	954		
Z score range		-2.9 to +6.79	
Z score > +2		77 (8.1%)	
Aortic Sinotubular Junction	1018		
Z score range		-3.52 to +4.85	
Z score > +2		99 (9.7%)	
Ascending Aorta	964		
Z score range		-4.01 to 4.25	
Z score > +2		45 (4.7%)	

P1-93

Effects of Sacubitril-Valsartan on Vascular Properties in Heart Failure Patients

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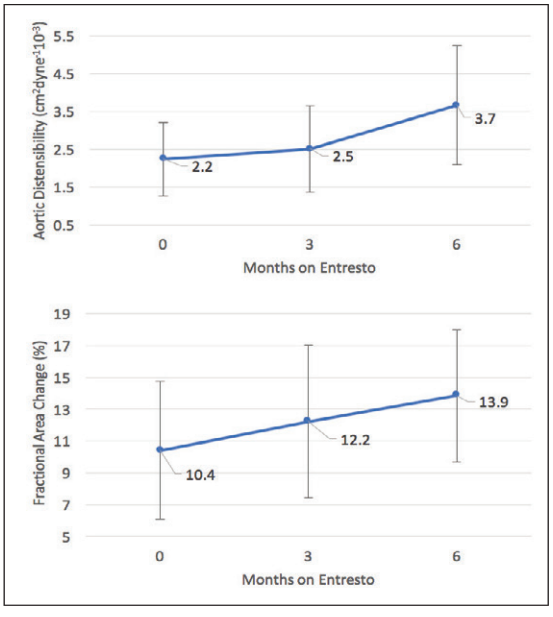
Background: Increased vascular stiffness is known to be a marker of poor prognosis in patients with heart failure with reduced ejection fraction (HFrEF). However, the effects of sacubitril-valsartan on vascular structure and function have not been systematically studied in this patient population. We hypothesized that aortic stiffness, as assessed by 2D transthoracic echocardiography (TTE), would improve over time in HFrEF patients undergoing sacubitril-valsartan therapy, and that these changes would be associated with clinical improvement. **Methods:** We prospectively studied 25 patients with HFrEF (25<EF<45%) on optimal guideline-directed medical therapy who were subsequently started on sacubitril-valsartan, as well as 25 age- and gender-matched normal controls. Patients underwent serial 2D TTE imaging at baseline, 3, and 6 months from the initiation of therapy. Ascending aortic diameters were measured 3 centimeters above the aortic valve in the parasternal long-axis view and used to calculate aortic distensibility and fractional area change, two markers of vascular stiffness. **Results:** Both indices progressively improved from baseline to 6 months (Figure). These changes were statistically significant: aortic distensibility (2.2±1.0 vs. 3.7±1.6 $cm^2dyne^{-1}10^{-3}$, p<0.0001) and fractional area change (10.4±4.3 vs. 13.9±4.2%, p=0.0001). Normal controls had lesser degrees of vascular stiffness than the HFrEF patients at any time point (mean aortic distensibility of 4.6±2.6 $cm^2dyne^{-1}10^{-3}$ and fractional area change of 20.0±7.7%). The changes in these markers over 6 months paralleled statistically significant improvements in 6-minute walk distance (p=0.02), KCCQ-12 score (p=0.002), and left ventricular ejection fraction (p=0.0007), as well as a non-significant trend towards decreased NT-proBNP levels (p=0.06). **Conclusions:** Aortic stiffness is increased in patients with HFrEF and gradually improves with sacubitril-valsartan treatment. These changes are associated with improvements in clinical and biochemical variables. The echocardiographic markers used in this study may become a useful tool to assess the effectiveness of sacubitril-valsartan therapy in HFrEF patients.



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P1-94

Vascular Abnormalities and Aortic Dilatation in Pediatric Patients with Bicuspid Aortic Valve

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Background: Bicuspid aortic valve (BAV) is the most common congenital heart disease with implications of valve dysfunction, associated coarctation of the aorta (CoA) and aortic dilatation. The etiology of aortic dilatation is not clear and may involve abnormal blood flow and inherent vascular abnormalities. Studies in adults have shown vascular dysfunction; however, less is known about the pediatric population. We sought to evaluate the vascular function in pediatric patients with BAV using echocardiography and tonometry. **Methods:** A prospective observational study was performed that examined vascular and ventricular function in patients with BAV compared to matched controls. Patients 7-18 years with BAV were included. Those with complex congenital heart disease were excluded (CoA was acceptable). Echocardiography was performed to assess aortic size, aortic vascular function (stiffness, distensibility, pulse wave velocity (PWV) and carotid intima media thickness), and ventricular function (systolic and diastolic). Carotid-femoral and carotid-radial PWV was assessed using tonometry. Ventricular and vascular function was compared between four patient groups stratified by aortic dilatation and a history of CoA. Multivariate regression analysis was performed on all patients to determine potential predictors of aortic dilatation. **Results:** One hundred forty-two BAV patients and age/sex-matched controls were studied. There were no significant differences between BAV subgroups. Aortic stenosis (AS) and insufficiency (AI) significantly influenced both ventricular and vascular measurements. In BAV patients without AS or AI, ascending aortas were stiffer and less distensible compared to controls. No differences were noted in carotid-femoral PWV. Multivariate regression revealed aortic arch PWV to be significantly associated with aortic dilatation (Table 1). **Conclusion:** Pediatric patients with BAV have differences in vascular function limited to their proximal aorta. Aortic arch PWV is significantly associated with aortic (sinus and ascending) dilatation. Carotid-femoral PWV is similar to controls and not associated with aortic dilatation. The observed difference in vascular function may be secondary to abnormal flow or a primary vascular abnormality restricted to the proximal aorta.

Table 1. Multivariate Regression Analysis for Ascending Aorta and Aortic Sinus Z-Score in Patients with BAV

Variable	Ascending Aorta Coef [95% CI]	P-value	Aortic Sinus Coef [95% CI]	P-value
Age (years)	-0.021 [-0.107, 0.066]	0.64	-0.032 [-0.115, 0.052]	0.45
Male	0.368 [-0.128, 0.864]	0.144	**0.881 [0.406, 1.356]**	**<0.001**
BAV Morphology	0.047 [-0.195, 0.289]	0.70	-0.036 [-0.266, 0.195]	0.76
History of Coarctation	**-0.701 [-1.251, -0.151]**	**0.013**	0.094 [-0.433, 0.620]	0.72
Aortic Insufficiency				
Mild	**-0.921 [-1.473, -0.369]**	**0.001**	**-0.697 [-1.224, -0.169]**	**0.010**
Moderate	**1.093 [0.439, 1.746]**	**0.001**	**0.956 [0.332, 1.580]**	**0.003**
Severe	1.101 [-0.114, 2.316]	0.075	0.997 [-0.154, 2.149]	0.089
Aortic Stenosis	0.547 [-0.259, 1.353]	0.182	-0.511 [-1.286, 0.264]	0.194
Aortic Stenosis Mean Gradient	-0.011 [-0.036, 0.014]	0.38	-0.018 [-0.042, 0.006]	0.142
Residual Coarctation	1.695 [-0.666, 4.057]	0.157	1.435 [-0.671, 3.540]	0.180
Residual Coarctation Peak Gradient	-0.023 [-0.077, 0.032]	0.41	-0.024 [-0.073, 0.025]	0.33
Carotid Femoral PWV	0.077 [-0.265, 0.419]	0.66	0.066 [-0.229, 0.361]	0.66
Aortic arch PWV	**0.151 [0.044, 0.258]**	**0.006**	**0.104 [0.009, 0.198]**	**0.031**
Ascending Aorta Distensibility	-1.126 [-2.982, 0.730]	0.23	-0.426 [-2.136, 1.285]	0.62
Abdominal Aorta Distensibility	0.006 [-1.535, 1.547]	0.99	0.048 [-1.411, 1.508]	0.95
Left carotid IMT	-1.956 [-7.022, 3.109]	0.44	-2.817 [-7.737, 2.103]	0.26
Right Carotid IMT	1.572 [-2.902, 6.046]	0.49	3.168 [-1.348, 7.685]	0.166

Coef Coefficient; IMT intima-media thickness; PWV Pulse Wave Velocity

P1-95

Changes of Left Ventricular Function in Patients with Aortic Stenosis and Aortic Regurgitation after Transapical Transcatheter Aortic Valve Implantation: A Three-Dimensional Speckle-Tracking Prospective Study

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Background: Transcatheter aortic valve implantation (TAVI) is an established treatment for high surgical risk aortic stenosis (AS) patient and expanded the indication to aortic regurgitation (AR) in recent years. The aim of this study was to determine the impact of transapical TAVI on the recovery of myocardial mechanics in both AS and AR patients. **Methods:** Thirty AR patients (70% men; mean age, 72.8±4.3 years) and thirty AS patients (53.3% men; mean age, 73.1±4.5 years) were enrolled. Conventional transthoracic echocardiography was performed for all patients before TAVI and 12 months after implantation. Three-dimensional (3D) speckle tracking was accomplished in twenty AR patients and twenty-four AS for the evaluation of global longitudinal strain, global circumferential strain, twist and rotation. **Results:** For AR patients, mean LV end-diastolic diameter (62.9±7.3 vs 52.0±6.8 mm, $p < .001$), LV stroke volume (110.6±26.4 vs 70.4±20.5 mL/beat, $p < .001$), LV mass index (179.8±52.2 vs 134.4±42.5 g/m2, $p = .001$) were relevantly decreased 12 months after TAVI. Interestingly, 3D global longitudinal strain (-17.2±3.2 vs -18.9±3.7, $p = .007$) and 3D global circumferential strain (-23.9±4.9 vs -25.7±5.0, $p = .008$) improved significantly while LV ejection fraction (57.0±10.3 vs 56.3±9.7 %, $p = .74$) was not significantly improved. As to AS patients, LV mass index (167.3±50.5 vs 117.6±31.7 g/m2, $p < .001$), LV ejection fraction (55.9±13.0 vs 61.7±8.6 %, $p = .01$), 3D global longitudinal strain (-16.1±4.6 vs -20.0±4.2, $p < .001$) as well as 3D global circumferential strain (-23.3±7.1 vs -26.7±4.6, $p = .003$) improved significantly. However, improvement of 3D twist and 3D torsion was not observed in both AR and AS patients. **Conclusions:** Our results indicate that LV function restored in myocardial deformation but not in rotational mechanics 12 months after TAVI in both AR and AS patient groups. Three-dimensional speckle tracking echocardiography appears to be a sensitive method to detect subtle cardiac remodeling after TAVI.

P1-96

Aortic Root and Valve Remodelling Before and After Aortic Valve Sparing Surgery: A 3D Echocardiographic Study

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Background: Aortic valve (AV) sparing operations are gaining in popularity because it avoids the morbidity and mortality associated with prosthetic valve replacement. However, the success of these operations is highly variable. Quantitative assessment of the aortic root and valve before and after surgery could provide measureable parameters that improve success. We aimed to use 3D transesophageal echocardiography (TEE) to quantitate the changes to the aortic root and valve before and after successful AV valve sparing operation. **Methods:** We studied 40 patients, 25 Controls (19 males, 60±10 years) and 15 with chronic aortic dilatation (11 males, 47±19 years) pre- and post AV sparing surgery. 3D-TEE images were analyzed at end-diastole using multi-planar reconstruction (QLAB, Philips) to obtain aortic root areas, diameters, and lengths. We also calculated a novel parameter called total coaptation surface area (TCoapSA), which sums the contact surface area of AV cusps. ANOVA and Student's t-tests were performed to compare groups. P<0.05 was considered significant. **Results:** In patients pre-AV sparing surgery, aortic root areas, inter-commissural distances, and cusp heights were significantly larger than controls, while cusp coaptation height and areas were significantly smaller (Table). After surgery, aortic root areas and inter-commissural distances were smaller than pre-surgery and not significantly different from Controls. Cusp coaptation height and areas were significantly larger compared to pre-surgery measurements and Controls. Nine of the 15 patients undergoing AV-sparing surgery had moderate or greater aortic regurgitation. No patient had moderate or severe AR after the intervention. **Conclusions:** Aortic root and valve remodeling in patients with chronic aortic dilatation can be quantified using 3D echocardiography. Pre-surgery, patients with aortic dilatation have larger root areas with smaller cusp coaptation areas. Successful AV sparing surgery addresses these changes with smaller root sizes and increased coaptation surface area. Quantitative assessment of the aortic valve and root could potentially help patient selection and surgical planning, while reducing operative times and the chances of complications.

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Table. Aortic geometry and coaptation parameters

	Control group (N=25)	Pre-operation (N=15)	Post-operation (N=15)	P between all groups
Aortic root areas				
Aortic annular area/BSA, cm^2/m^2	2.07 ± 0.40	2.85 ± 0.52#	2.85 ± 0.52†	<0.001
SoV/BSA, cm^2/m^2	3.87 ± 0.91	7.37 ± 1.22#	3.21 ± 1.12§	<0.001
Inter-commissural distances, cm				
RN-NL	2.25 ± 0.28	3.08 ± 0.28#	2.04 ± 0.39§	<0.001
NL-LR	2.24 ± 0.27	2.99 ± 0.29#	2.14 ± 0.34§	<0.001
LR-RN	2.28 ± 0.28	3.07 ± 0.34#	2.15 ± 0.29§	<0.001
Cusp heights				
Effective height, cm	1.18 ± 0.17	1.36 ± 0.19#	1.4 ± 0.31†	0.005
Cusp height, cm				
Right	1.61 ± 0.21	1.80 ± 0.18#	1.66 ± 0.22	0.023
Non	1.57 ± 0.23	1.79 ± 0.20#	1.62 ± 0.25§	0.011
Left	1.52 ± 0.21	1.73 ± 0.14#	1.62 ± 0.25	0.008
Coaptation parameters				
Average coaptation heights, cm				
Medial	0.58 ± 0.10	0.45 ± 0.13#	0.77 ± 0.21†§	<0.001
Lateral	0.74 ± 0.15	0.57 ± 0.16#	0.86 ± 0.20†§	<0.001
Medial and lateral	0.66 ± 0.10	0.51 ± 0.13#	0.81 ± 0.19†§	<0.001
Coaptation lengths, cm				
R-N	1.11 ± 0.16	1.25 ± 0.17#	1.14 ± 0.11§	0.02
N-L	1.14 ± 0.14	1.31 ± 0.15#	1.06 ± 0.12§	<0.001
R-L	1.10 ± 0.16	1.27 ± 0.14#	1.08 ± 0.14§	0.001
Coaptation surface area				
Total CoapSA, cm^2	2.23 ± 0.48	1.98 ± 0.62	2.68 ± 0.70†§	0.007
Total CoapSA/Aortic annular area	0.57 ± 0.15	0.36 ± 0.14#	0.48 ± 0.13†§	<0.001

Data are presented as mean±SD. AR, aortic regurgitation; BSA, body-surface area; CoapSA, coaptation surface area; N-L, non-left; R-L, right-left; R-N, right-non; SOV, sinus of Valsalva.
#, $p < 0.05$ for Independent Samples T-test between Control group and Pre-operation group
†, $p < 0.05$ for Independent Samples T-test between Control group and Post-operation group
§, $p < 0.05$ for Independent Samples T-test between Pre- and Post-operation

P1-97

Offspring of Mothers with Diabetes Mellitus have Altered Arterial Stiffness into Early Childhood

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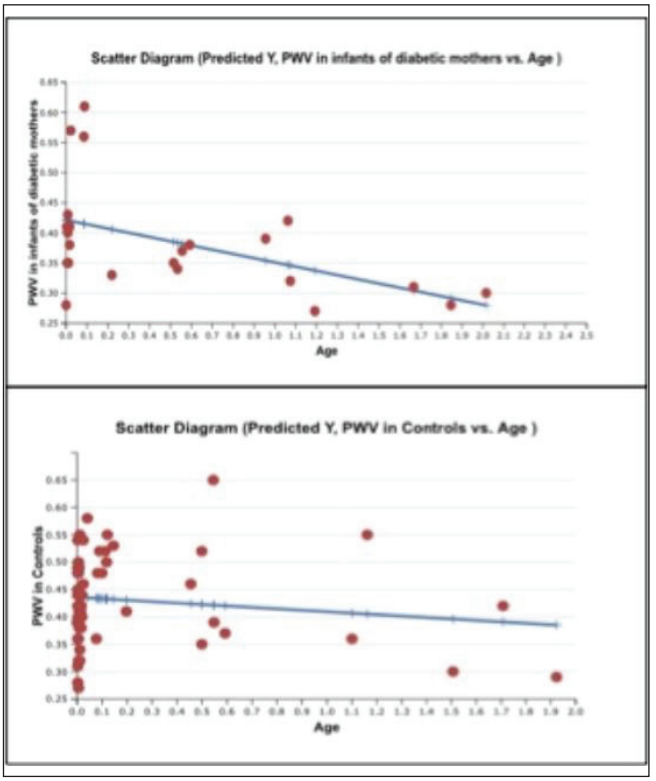
Background: Offspring of mothers with diabetes mellitus (OMDM) are known to have higher systolic blood pressure. Hypothesis of this study is that fetal programming alters arterial stiffness (AS) in OMDM and plays a role in cardiovascular disease (CVD). Arterial stiffness can be measured using pulse wave velocity (PWV). **Purpose:** This prospective study explores the hypothesis by comparing AS in OMDM to normal controls (NC) using PWV. **Methods:** Neonates born to MDM and healthy mothers without any systemic disease (NC) were prospectively recruited. After maternal informed consent, blinded echocardiograms and ten spectral PW Doppler waveforms were performed in the right common carotid artery (RCA) in the neck and R femoral artery (RFA) in the groin at same heart rates using appropriate transducer on GE Vivid XD. The time delay between the foot of the waveform at the two sites was obtained by gating to the peak R wave on the electrocardiogram (t). Mean of 10 recordings was used. The distance (d) traveled by the waveform was calculated by subtracting the distance between the second intercostal space and the sampling site on the RCA from the sum of second intercostal space to the inferior edge of the umbilicus and inferior edge of the umbilicus to the sampling site on the RFA. PWV= d/t. Serial measurements were made from birth-2 years. Statistical comparisons were made using Students' t test and regression analysis was performed to determine best fit for PWV. **Results:** Seventy-six studies were performed on 15 OMDM and 25 NC. Mean gestation age ± standard deviation (SD) (OMDM- 38.7±1.4, NC-39+0.4 weeks), birth weight (3.4±0.6 vs 3.2±0.5 kg) and length (49.8±2.8 vs 49.4+2.3 cm) were similar in the 2 groups. Mean maternal Hgb A1c in NMDM was 5.8%. Mean PWV at birth in OMDM was 0.36±0.07, decreased to 0.29±0.02 by 2 yrs (PWV= 0.421-0.07*Age, R=0.5, p<0.05). Mean PWV at birth in NC was 0.45±0.12, decreased to 0.35+0.06 by 2 years (PWV= 0.436-0.026*Age, R=0.14, p=0.3) (Figure). Global longitudinal strain (GLS) was similar at birth (-15.15+3.3 vs -15.0+2.9, p=0.9), but lower in OMDM at 2 yrs (-16.7+4.2 vs -23.2+1, p<0.01). **Conclusion:** Arterial stiffness and GLS are different in OMDM in the first 2 yrs of life compared to NC. This may affect their long-term cardiovascular health. Longitudinal follow-up is required to evaluate for long-term CVD risk.



P1-98

Impact of Chronic Aortic Root Dilatation on Aortic Valve Remodelling and Coaptation

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Background: Chronic aortic root dilatation causes aortic cusp tethering, which leads to cusp remodeling. However, little is known about the interaction between indexes of cusp coaptation, cusp remodeling and aortic regurgitation (AR) severity. The aim of this study was to examine the effect of chronic aortic dilatation on aortic cusp size, coaptation area and regional coaptation length with respect to aortic regurgitation. **Methods:** Three-dimensional transesophageal echocardiography was performed in 40 patients, 25 Controls (19 males, 60±10 years) and 28 with aortic dilatation divided into those with ≤mild AR (Group 1, N=13, 11 males, 39±19 years) and ≥moderate AR (Group 2, N=10, 3 males, 55±15 years). 3D-TEE images were analyzed at end-diastole using multi-planar reconstruction (QLAB, Philips) to obtain aortic root areas, diameters, lengths and coaptation surface area. ANOVA and Student's t-tests were performed to compare groups. P<0.05 was considered significant. **Results:** Compared to Controls, Groups 1 and 2 had significantly larger aortic root areas, inter-commissural distances and cusp heights (Table 1). Compared to Group 1 and Controls, Group 2 had significantly smaller total surface coaptation area when adjusted for aortic annular area (p=0.001) with shorter coaptation height (p<0.001). **Conclusions:** The aortic valve is a dynamic structure that remodel in response to aortic dilatation. Significant regurgitation is associated with a loss of coaptation surface area. Quantitative modeling of the aortic valve and root could potentially provide information for tailored aortic valve repair surgeries.

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	Control group (N=25)	Group 1 Dilated ≤ mild AR (N=13)	Group 2 Dilated moderate-severe AR (N=10)	P between all groups
Aortic root areas				
Aortic annular area/BSA, cm^2/m^2	2.07 ± 0.40	2.98 ± 0.62 #	2.77 ± 0.66 †	<0.001
SoV/BSA, cm^2/m^2	3.87 ± 0.91	7.08 ± 1.54 #	7.47 ± 1.52 †	<0.001
Inter-commissural distances, cm				
RN-NL	2.25 ± 0.28	3.14 ± 0.31#	2.89 ± 0.25 †	<0.001
NL-LR	2.24 ± 0.27	3.00 ± 0.33 #	2.92 ± 0.36 †	<0.001
LR-RN	2.28 ± 0.28	3.16 ± 0.34 #	2.99 ± 0.28 †	<0.001
Cusp heights				
Effective height, cm	1.18 ± 0.17	1.43 ± 0.23 #	1.26 ± 0.17	0.002
Cusp height, cm				
Right	1.61 ± 0.21	1.80 ± 0.16 #	1.78 ± 0.19 †	0.01
Non	1.57 ± 0.23	1.87 ± 0.16 #	1.68 ± 0.13 §	<0.001
Left	1.52 ± 0.21	1.72 ± 0.14 #	1.67 ± 0.12 †	0.003
Coaptation parameters				
Average coaptation heights, cm				
Medial	0.58 ± 0.10	0.52 ± 0.11	0.45 ± 0.12 †	0.009
Lateral	0.74 ± 0.15	0.69 ± 0.15	0.53 ± 0.14 †, §	0.002
Medial and lateral	0.66 ± 0.10	0.60 ± 0.12	0.49 ± 0.11 †, §	0.001
Coaptation lengths, cm				
R-N	1.11 ± 0.16	1.35 ± 0.15 #	1.29 ± 0.21 †	<0.001
N-L	1.14 ± 0.14	1.36 ± 0.15 #	1.29 ± 0.17 †	<0.001
R-L	1.10 ± 0.16	1.35 ± 0.16 #	1.26 ± 0.10 †	<0.001
Coaptation surface area				
Total CoapSA, cm^2	2.23 ± 0.48	2.50 ± 0.73	1.90 ± 0.46 §	0.048
Total CoapSA/Aortic annular area	0.57 ± 0.15	0.41 ± 0.13 #	0.39 ± 0.13 †	0.001
Total CoapSA/SoV area	0.30 ± 0.07	0.17 ± 0.04 #	0.14 ± 0.04 †	<0.001

Data are presented as mean±SD. AR, aortic regurgitation; BSA, body-surface area; CoapSA, coaptation surface area; N-L, non-left; R-L, right-left; R-N, right-non; SOV, sinus of Valsalva.
#, $p < 0.05$ for Independent Samples T-test between Control group and Group 1
†, $p < 0.05$ for Independent Samples T-test between Control group and Group 2
§, $p < 0.05$ for Independent Samples T-test between Group 1 and Group 2

P1-99

Effect of Transcatheter Aortic Valve Replacement on Left Atrial Volume

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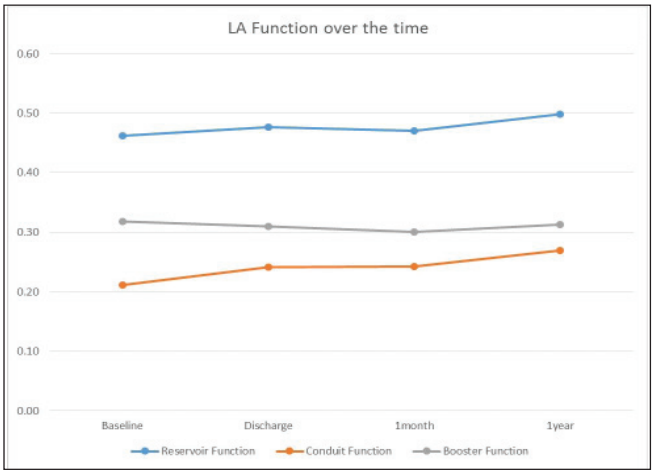
Background: Severe aortic stenosis causes a marked increase in left ventricular (LV) afterload, with resultant left ventricular hypertrophy as well as changes of LA volume and function. LA size as an imaging biomarker has been consistently shown to be a powerful predictor of outcomes such as atrial fibrillation, heart failure, stroke and death. Our study assessed the effect of transcatheter aortic valve replacement on left atrial volumetric function and left atrial volume for the prediction of adverse outcomes. **Methods:** 121 patients in sinus rhythm who underwent TAVR for severe AS were included. Maximum LA volume index (LAVI max), minimum LA volume index (LAVI min), and "pre-A" volume index were measured at baseline, 1 month, and 1 year. Reservoir, conduit and booster function were calculated. Endpoints included new onset AF and all-cause mortality **Results:** The reservoir function, conduit function and booster function before TAVR were 46%, 21%, 32%, respectively. LA volumetric function assessment demonstrated that reservoir function, conduit function increase over the time (all P < 0,001). There was no difference in booster function after TAVR (p=0.06). The overall accuracy for the prediction of AF was greater for LAVI max than that of the LAVI min and LAVI pre-A (AUR for LAVI max 0.67 versus 0.65 and 0.64 for LAVI pre-A and LAVI min). At the baseline, LAVI max was not associated with all-cause of mortality, but a higher rate of new onset AF (HR: 1.03; 95% CI, 1.01-1.05; p = 0.02) after adjustment for other significant risk factors but only severely abnormal LA size significantly increased risk for AF (HR: 4.72; 95% CI, 1.11-20.13, p = 0.04). There was a progressive decrease in LAVI max over the time in non-AF group (overall P < 0.05) but not in AF group (overall P > 0.05). **Conclusion:** Reservoir function, conduit function increased over time. Lack of negative remodeling post TAVR was associated with higher incidence of AF



P1-100

Evaluation of Aortic Stiffness by 2D Speckle Tracking Aortic Strain

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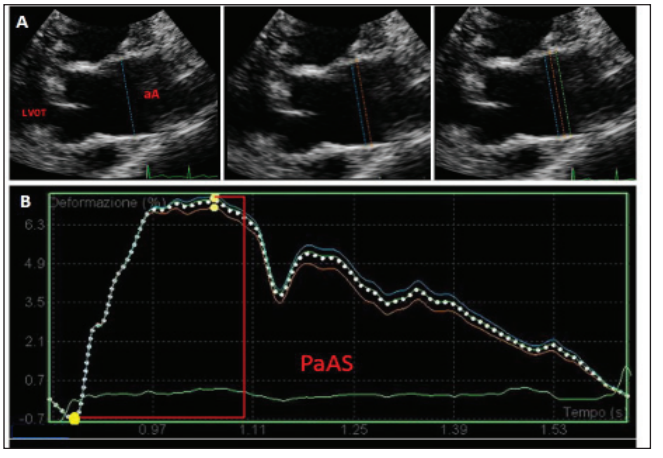
Background: Arterial stiffness is a marker of cardiovascular damage and an independent predictor of major cardiovascular events. It is usually assessed via Carotido-Femoral Pulse Wave Velocity (cfPWV). Strain analysis from cardiac resonance and computed tomography has been used to describe aortic stiffness. **Aim:** of this study was to test the feasibility of aortic strain analysis using speckle tracking on transthoracic echocardiography (TTE), its association with cfPWV, and its behavior in individuals with and without ascending aorta (aA) Dilatation. **Method:** 60 consecutive patients with normal blood pressure and aortic dimensions underwent TTE and cfPWV evaluation with validated instrument (Sphygmocor System). Strain analysis was performed on the largest section of the aA with a dedicated software (Philips Qlab); 3 couples of speckles were identified within the anterior and posterior aortic wall, and transverse segments connecting each couple were traced - fig.1A. *Peak ascending Aorta Strain* (PaAS) was defined as the averaged peak percentage deformation of the 3 segments during a cardiac cycle - fig.1B. The same workflow was applied to 22 patients with known aA dilatation. **Results:** 14 controls were excluded for suboptimal TTE images. In the 43 analyzed individuals (male 58%, age 58y), cfPWV was 8.0 ± 1.75 m/sec and PaAS was 7.58 ± 4.82%, without significant differences between genders. Inter- and intra- observer variability were good for PaAs (Interclass correlation coefficient = 0.88 and 0.73, confidence intervals -0.68 to +0.81 and -0.1 to 0.94 respectively). PaAS showed significant correlation with age (r = -0.65, p< 0.001), aA diameter (r= -0.42, p=0.005), cfPWV (r= -0.48, p=0.004), stroke volume (r=0.40, p= 0.008) and heart rate (r=-0.50, p<0.001). PaAs was significant lower in patients with dilated aA (1.89 ±1.84%, p<0.001 vs. controls). Logistic regression showed that PaAS but neither age, gender, heart rate, stroke volume or cfPWV were significant predictors of aA dilatation. **Conclusion:** Speckle tracking TTE based strain analysis of the aA is feasible and reproducible. PaAS is associated with cfPWV, the gold standard measure of aortic stiffness, and is significantly reduced in patients with dilated aA.



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P1-101

Aortic Symmetry Index - Initial Validation of a Novel Preoperative Predictor of Recurrent Aortic Insufficiency After Valve Sparing Aortic Root Reconstruction

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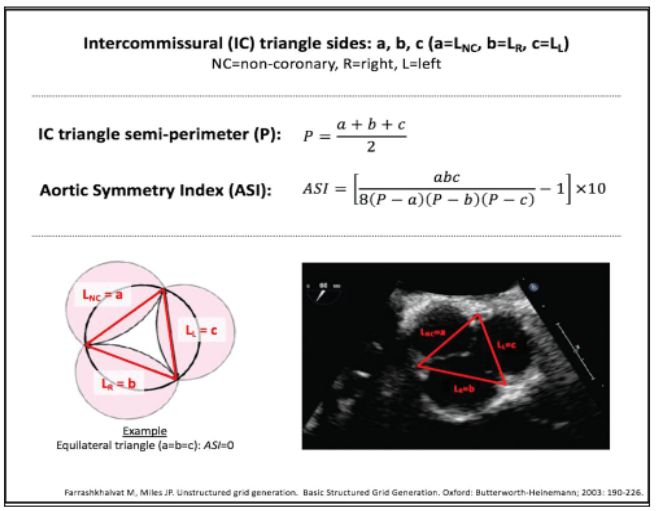
Background: Valve-sparing aortic root replacement (VSRR) has become increasingly favored over traditional valve replacement for patients with advanced aortic insufficiency (AI) because of its lower incidence of thromboembolic events, reduced risk of endocarditis, and avoidance of anticoagulation. Studies on determinants of recurrent AI after VSRR have primarily focused on post-repair measurements (e.g.: coaptation length). However, a pre-operative predictor of successful VSRR would hold the potential to influence the timing of surgical indication, similarly to what happens in mitral valve surgery. This proof-of concept study tested a novel pre-operative transesophageal echocardiographic (TEE) predictor of recurrent AI among patients undergoing VSRR. **Methods:** All patients with native trileaflet aortic valve (AV) undergoing VSRR at our institution (Weill Cornell Medicine, NY) between 2006-2015 were included. Pre-procedural TEE was used to quantify the degree of AV symmetry in short-axis view: inter-commissural distances at end-diastole were measured to identify the "inter-commissural triangle". An "aortic symmetry index" (ASI) was defined according to the inter-commisural triangle aspect ratio, expressed in terms of the lengths of the sides; ASI=0 for an equilateral triangle and it progressively increases as the three sides differ from each other (details and formulas in **Figure**). Goal was to test whether ASI predicted advanced AI (≥3+) at follow-up. **Results:** TEE datasets were available for 67 patients with native trileaflet AV (47.6±14.7 yo, 78% male, 31% connective tissue disorders). At mean follow-up of 2.9±2.6 years, all patients were alive; 5.9% developed recurrent advanced AI, no patient was reoperated on the AV. Follow-up was 100% completed. ASI was quantifiable in 98.5% of cases and yielded excellent intra- and inter-observer reproducibility (Δ: -0.06±0.10 and -0.04±0.07, respectively). Magnitude of AV symmetry was significantly higher (i.e., ASI closer to 0) in patients with AI= 0 vs those with advanced AI at follow-up (0.09±0.07 vs 0.25±0.12, respectively; p<0.001). **Conclusion:** ASI is a promising pre-operative index of valve symmetry in patients with tricuspid AV undergoing repair, and is associated with the degree of follow-up AI. Further data are necessary to validate this index.



P1-102

Thoracic Aortic Thrombus: Diagnostic Modalities and Echocardiographic Features

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Background: Thoracic aortic thrombus (TAT) is a rare condition that has been reported only in small case series. The optimal diagnostic modality and typical clinical and imaging characteristics have not been well-defined. **Methods:** Patients diagnosed with TAT at our institution between January 2000 and July 2017 were included. **Results:** Sixty patients with TAT were identified. Patient characteristics are detailed in Figure 1. Initial diagnostic modalities included transthoracic echocardiogram (1.7%), transesophageal echocardiogram (25.0%), noncontrast CT chest (20.0%), and CT angiogram (50.0%). Of those diagnosed with TEE, the primary indication for imaging was to assess for source of emboli in patients with peripheral arterial embolism (12/15). One thrombus was found incidentally during TEE to evaluate severe aortic stenosis and two were detected during TEE to rule out endocarditis. Of the thirty patients diagnosed with CT angiogram, ten underwent subsequent TEE, primarily to evaluate an intrathoracic aortic mass incompletely visualized on CTA abdomen/pelvis or CTA head/neck (6/10). One TEE was completed for question of intraaortic angiosarcoma and three were obtained intraoperatively during endovascular procedures. Echocardiographic features of the thoracic aortic thrombi are detailed in Figure 1. Atherosclerosis was the suspected etiology in 27 (45.0%) cases. Five (8.3%) cases were associated with aneurysm. Hypercoagulable states were detected in 15 (25.0%) patients, primarily antiphospholipid antibody syndrome (4), metastatic malignancy (4) and JAK-2 positive myeloproliferative disorders (3). **Conclusion:** TAT is a rare entity, associated with significant morbidity. The most common diagnostic modalities include TEE and CT angiogram of the chest. Thrombus size and location can be determined with either modality. TEE can assess TAT mobility and evaluate for associated aortic wall or intracardiac abnormalities. CTA is most useful in determining the presence and location of peripheral embolism or related tissue infarction.

Figure 1. TAT Patient Characteristics and Echocardiographic Features

Patient Characteristics	
Gender, n (%)	
Female	32 (53.3)
Male	28 (46.7)
Age at Diagnosis (years), n (%)	
20-39	7 (11.7)
40-59	15 (25.0)
60-79	28 (46.7)
80-99	10 (16.7)
Presenting Symptoms, n (%)	
None	26 (43.3)
Abdominal pain	20 (33.3)
Lower extremity pain	9 (15.0)
Neurologic deficit	4 (6.7)
Chest pain	1 (1.7)
Site of Distal Embolism at Presentation, n (%)	
None	27 (45.0)
Multifocal	15 (25.0)
Lower extremity	14 (23.3)
Spleen	13 (21.7)
Bowel	9 (15.0)
Kidney	7 (11.7)
Brain	4 (6.7)
Liver	1 (1.7)

Echocardiographic Features	
Proximal TAT Location, n (%)	
Ascending aorta	2 (8.0)
Aortic arch	3 (12.0)
Descending aorta	20 (80.0)
Thrombus Mobility, n (%)	
Immobile	5 (20.0)
Mobile	20 (80.0)
Thrombus Size (mm)	
Maximum diameter	18.9 ± 14.1
Thoracic Aorta Abnormalities, n (%)	
Aortic atherosclerosis	18 (72.0)
TAT aneurysm	2 (8.0)
TAT attachment site	
Atheroma	16 (64.0)
Wall-thickening	6 (24.0)
Additional TEE Characteristics, n (%)	
LVEF	
< 50	1 (4.0)
50-59	6 (24.0)
≥ 60	17 (68.0)
NA	1 (4.0)
Atrial septal defect	4 (16.0)
Intracardiac thrombus	0 (0.0)
Valvular vegetation	2 (8.0)

P1-103

Aortic Size in Children: Systolic Measurements Are Different from Diastolic Measurements

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Background: Normal reference values for aortic size are crucial in the care of children with heart disease. The timing of measurements during the cardiac cycle is controversial: the American Society of Echocardiography recommends diastolic measurements in adults and systolic measurements in children. Studies have shown significant systolic-to-diastolic (SD) differences in the same subject, though a recent adult study suggests that these SD differences are not clinically significant. Because aortic measurements in children reportedly vary by at least 5% among multiple observers, SD differences <5% are likely due to measurement variability and not clinically important. We sought to characterize SD differences in healthy children with this in mind. **Methods:** This retrospective study enrolled all children (age 1 month to 19 years) with a complete echocardiogram and no significant heart disease from random days between January and December 2016. Observer 1 measured the aorta at the annulus (ANN), root (AOR), sinotubular junction (STJ), and ascending aorta (AAO) during systole and diastole using standard methodology. Systolic and diastolic values were compared by calculating the mean SD percent difference for each segment; if the SD difference was >5%, it was considered clinically important. Observer 2 made the same measurements in 18% of the subjects, and agreement with observer 1 was tested by calculating intraclass coefficient. **Results:** For the 272 study subjects, systolic measurements were larger than diastolic measurements with mean SD percent differences >5% (p<0.001) for the AOR (7.3% ± 5.5%), STJ (10.24% ± 7.1%), and AAO (9.8% ± 7.4%). There was no clinically important SD difference for the ANN (4.4% ± 8.1%, p=0.885). There was excellent intraclass correlation coefficient between observers (0.982-0.995). **Conclusion:** Systolic measurements for the AOR, STJ, and AAO are significantly larger than diastolic measurements. Normal reference values are used to plan treatment for patients with abnormal aortic sizes, and the timing in the cardiac cycle used to determine the reference values should be the same as the timing used to make measurements in clinical practice. This is especially important as patients transition their care from a pediatric to an adult cardiologist.

P1-104

Pulse Pressure Following Transcatheter Aortic Valve Replacement Correlates with Clinical Outcomes

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Background: Transfemoral aortic valve replacement (TAVR) has become the primary method of aortic valve replacement for many patients with aortic stenosis (AS).

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Identifying factors associated with both positive and negative outcomes after TAVR will be central to wider application of this technology. Given the powerful prognostic ability of pulse pressure (PP) in hypertensive cohorts, we evaluated the relationship between PP and clinical outcomes in a single center, 192-patient TAVR database. **Methods and results:** Patients undergoing TAVR were divided into two groups based on the change in PP between baseline (pre-TAVR) and discharge. In Group A (n=45), PP decreased 10 mmHg or more; Group B (n=147) included all others. Hospitalizations and mortality at one year were compared between groups. Overall, PP rose slightly between baseline and discharge (61 to 66 mmHg) but returned to baseline by 1 month, and remained stable at 1 year. Group A and Group B displayed different patterns of PP: (Table) Group A started higher and decreased (average 24 mmHg) at discharge, Group B started lower and rose (average 16 mmHg) at discharge. At 1 month and 1 year, the groups had similar PP's. At one-year, group A tended to have fewer hospitalizations (0.56 all-cause hospitalizations per patient vs. 0.67 for group B, p=0.27) although all cause deaths were similar (9% vs 14% for group B, p=0.49). **Conclusions:** An early drop in PP post-TAVR appears to be associated with improved clinical outcomes and may reflect greater vascular compliance in this cohort. PP change post TAVR may provide prognostic information and merits further study.

	Baseline	Discharge	One month	One year
Overall	61± 17	66±18	63±19	63±19
Group A*	78±16	54±14	63±17	60±17
Group B*	55±17#	71±21#	63±20	65±20

* Overall trend p<0.05
# p< 0.05 vs. group A

P1-105 — Moderated Poster

Differences in Flow-Gradient Patterns between Severe Bicuspid Aortic Stenosis and Severe Tricuspid Aortic Stenosis: Mechanistic Insight from Multimodal Imaging

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Background: Although flow-gradient pattern in AS provides prognostic information, there is limited data on patterns in bicuspid AS. Our objective was to investigate flow-gradient pattern characteristics and associated factors in severe bicuspid aortic stenosis (AS) compared with severe tricuspid AS. **Methods:** A total of 252 patients with severe AS (115 bicuspid vs. 137 tricuspid) who underwent aortic valve (AV) replacement were retrospectively analyzed. Patients were classified into 4 groups according to stroke volume index and mean pressure gradient across the AV [normal-flow high-gradient (NF-HG), low-flow high-gradient, normal-flow low-gradient, low-flow low-gradient (LF-LG)]. In 89 patients who underwent cardiac computed tomography (CT), structural parameters among left ventricular outflow track (LVOT), AV and ascending aorta were assessed. **Results:** Bicuspid AS was more likely to present a NF-HG pattern (83.5 vs. 64.2%, p<0.001), while significantly fewer patients presented a LF-LG pattern compared to tricuspid AS (Figure 1). In bicuspid AS, there was a significant mismatch between geometric orifice area (GOA) on CT planimetry and effective orifice area (EOA) calculated using the echocardiographic continuity equation compared to tricuspid AS (Figure 2). Bicuspid AS presented with a larger angle between the LVOT-AV and aorta. Multivariate analysis of bicuspid AS revealed that systemic arterial compliance (β=-0.350, p=0.0.031) and LVOT-AV and aorta angle (β=-0.538, p=0.001) are associated with a discrepancy between GOA and EOA after controlling for age, stroke volume index, and ascending aorta diameter. **Conclusions:** Flow-gradient patterns in severe bicuspid AS vary from those of tricuspid AS and are associated with the structural and functional characteristics of the aorta.

Figure 1

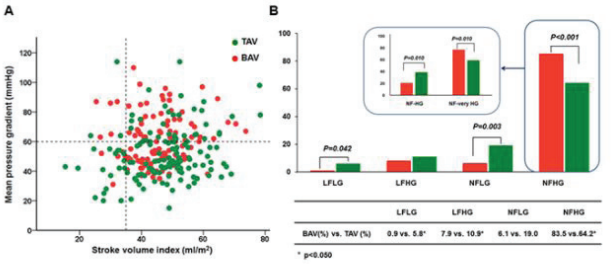
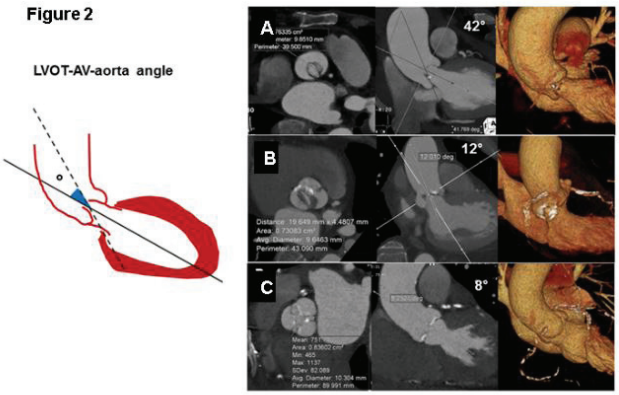


Figure 2



A. Bicuspid AS with higher discrepancy between effective orifice area and geometric orifice area (ratio: 0.52) is presented with larger LVOT-AV and aorta angle (42°)
B. Bicuspid AS with less discrepant effective orifice area and geometric orifice area (ratio: 1.10) is presented with smaller LVOT-AV and aorta angle (12°)
C.Tricuspid AS without significant discrepancy between effective and geometric orifice area (ratio: 1.04) is presented with LVOT-AV and aorta angle (8°)

P1-106

Projected Aortic Valve Area by Six-minute Walk Stress Echocardiography Improves Predictive Value in Patients with Significant Aortic Stenosis

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Background: There is a paucity of an investigation of six-minute walk stress echocardiography (6WSE) for patients with aortic stenosis (AS). We aimed to assess the value of 6WSE to predict the prognosis of AS patients. **Methods:** We prospectively enrolled consecutive 122 ambulant patients with moderate to severe AS who underwent 6WSE from June 2016 to December 2017. NYHA functional class was I or II in all patients. We excluded patients with atrial fibrillation or left ventricular outflow obstruction. AVA was calculated by the continuity equation at baseline and at 6WSE. Projected AVA at a normal transvalvular flow rate (250mL/sec) was calculated at 6WSE. Primary endpoints were defined as all cause death, hospitalization for heart failure, and the need for aortic valve replacement including trans-catheter aortic valve replacement. We assessed the accuracy of projected AVA to predict endpoints in AS patients. **Results:** 112 patients were evaluated in the present study. The mean age was 78±8.5 years old. 42 patients were male. 6WSE was performed safely in all patients without complications although six-minute walk was aborted in seven patients because of symptoms (two had dyspnea, two had chest pain and three had fatigue). 40 patients (36%) had events during follow up period. The sensitivity, specificity, and accuracy for endpoints were 100%, 10%, and 69% for baseline AVA no more than 1.0 cm^2. On the other hand, area under the curve for projected AVA was 0.84 and the cutoff value was 0.88cm^2. The sensitivity, specificity, and accuracy for endpoints were 93%, 65%, and 77% for projected AVA less than 0.88cm^2. Projected AVA less than 0.88cm^2 was associated with reduced event-free survival (figure). **Conclusion:** Projected AVA by 6WSE is a safe and powerful predictor in patients with moderate to severe AS with NYHA I or II.

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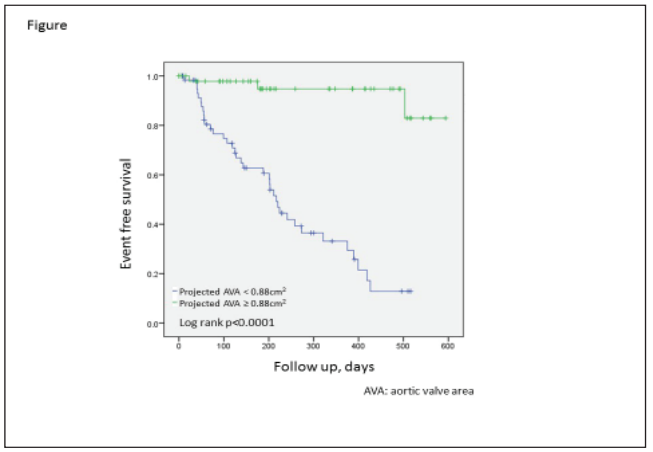

P1-107

Orifice Eccentricity Accentuates Flow Disturbance Due to Severe Mitral Annular Calcification

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Background: Mitral annular calcification (MAC) is a degenerative disease which deforms the valve and reduces its opening. It is prevalent in the elderly and those with renal insufficiency. The narrowed orifice may disturb vortex formation in the left ventricle (LV) thus contributing to symptoms of dyspnea and effort intolerance. **Methods:** Experimental measurements were performed on a cardiac duplicator using simple models of the mitral annulus. Severe stenosis with three orifice eccentricities (e=0; e=0.22, and e=0.44) was simulated. Stroke volume (70 ml), heart rate (70 bmp), and mean aortic pressure (100 mmHg) were held constant. Time-resolved particle image velocimetry was performed characterizing the LV flow field in terms of velocity, viscous energy losses, and vortex formation time. We separately evaluated 3d images from patients with severe MAC to determine the degree and range of orifice eccentricity in a clinical sample. **Results:** Severe MAC induced significant changes in LV flow patterns characterized by higher shear flow and more complex particle transport. There were significant increases in viscous energy losses, related to MAC severity and orifice eccentricity, up to 5.5 times normal. Vortex formation time was similarly affected by MAC severity and orifice eccentricity, with values up to 14.28 (normal 3.5-5.5). In 13 patients with severe MAC, major axis eccentricity ranged from 0.05-0.25 (median=0.15); minor axis eccentricity ranged from 0.04-0.54 (median=0.22). **Conclusions:** Severe MAC has significant effects on vortex formation which are accentuated by a more eccentric orifice. 3D TEE in a patient sample with severe MAC confirms the presence of orifice eccentricity, making the in-vitro results clinically relevant.

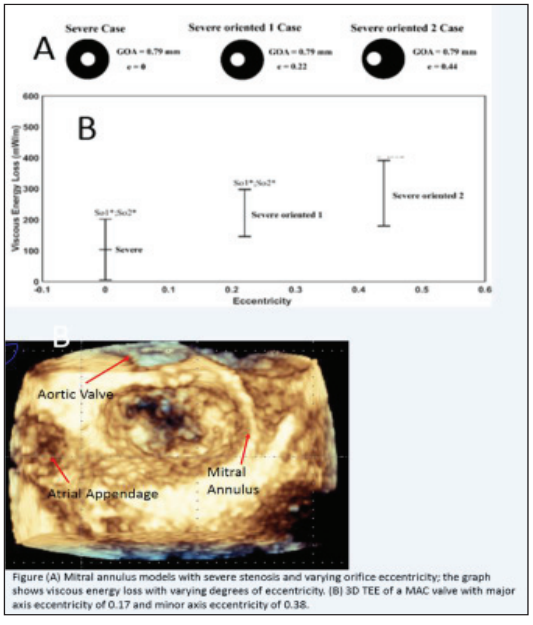

Figure (A) Mitral annulus models with severe stenosis and varying orifice eccentricity; the graph shows viscous energy loss with varying degrees of eccentricity. (B) 3D TEE of a MAC valve with major axis eccentricity of 0.17 and minor axis eccentricity of 0.38.

P1-108

Left Atrial Mechanical Function and Clinical Outcome After Percutaneous Mitral Valve Repair with the MitraClip in Patients With and Without Atrial Fibrillation

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Background: Successful MitraClip therapy improves clinical outcomes in high-risk patients with mitral regurgitation (MR), but not all patients benefit to similar degree. The goal of this study was to analyze whether left atrial (LA) mechanical function had any impact of clinical outcomes after MitraClip procedure. **Methods:** Consecutive patients undergoing MitraClip implantation between 2014 and 2017 were enrolled. TTE assessment of LA mechanical function (reservoir, conduit, and contractile LA strain) was performed by speckle tracking at baseline, short term (1-2 months) and 1 year follow-up. Functional parameters including 6-minute walk distance (6MWT), NYHA class, NT-Pro BNP were also recorded. **Results:** A total of 103 patients were included; age was 79.5±8.5 yrs and 31 (30%) were female. Atrial fibrillation (AF) was present in 69 (67.0%), and sinus rhythm in 34 (33.0%). MR was degenerative in 60% patients. LA mechanical function, functional and clinical parameters are given in the table. Patients with AF had lower LA reservoir strain and left ventricular (LV) global longitudinal strain (GLS) at all time-points. Despite significant reduction in MR severity, LA reservoir strain remained unchanged. Furthermore, in AF patients, LV GLS and LA volume reservoir strain continued to decrease at long term follow-up. There was no correlation between baseline LA mechanical function and observed clinical improvement or changes in functional and laboratory parameters. **Conclusion:** Patients with AF have worse LA and LV mechanical function at baseline; these differences persist at short-term and 1-year follow-up despite significant reduction in MR. These findings suggest that AF is associated with a more advanced form of atrial and ventricular myopathy. Baseline LA mechanical function does not seem to predict changes in functional parameters after MitraClip.

		AF (N=69)			SR (N=34)	
	baseline	Short term	1 year	baseline	Short term	1 year
MR grade	3.6±0.5	2.1±0.8*	2.3±1.0*	3.9±0.2	2.2±1.2 *	2.8±1.1*
LA Res strain(%)	12.6±6.4	12.4±7.0	9.9±3.6	20.4±6.4**	20.0±7.0 **	16.7±5.9**
GLS	-12.8±3.9	-12.7±3.5	-10.9±3.0*	-16.1±4.2	-15.6±3.3	-14.5±3.5
6MWT(m)	306±89	312±113	355±89	344±116	345±115	356±104
NT-pro BNP (pg/dL)	4490±6656	2419±4226	3818±3968	4158±6766	4392±7938	4316±4454
NYHA class N(%)						
I	0(0)	28(40.6)	9(22.5)	0(0)	18(54.5)	5(27.8)
II	2(2.9)	27(39.1)	12(30)	3(8.9)	8(24.2)	8(44.4)
III	50(72.4)	13(18.9)	17(42.5)	25(73.5)	7(21.2)	5(27.8)
IV	17(24.6)	1(1.4)	2(5.0)	6(17.6)	0(0)	0(0)

*p<0.05 vs. baseline; **p<0.05 vs. AF

P1-109

Functional 3D Printed Modeling of Mitral Valve Regurgitation for Structural Heart Intervention

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Background: MitraClip procedure is a novel structural heart intervention increasingly applied in patients with severe mitral regurgitation (MR) and prohibitive surgical risk. It has been shown that 3D printed models have potential to facilitate the procedural planning of such percutaneous interventions. **Methods:** 3D transesophageal echocardiographic (TEE) systolic images of six patients with MR were acquired (iE33) and exported as Cartesian DICOM imaging format into segmentation software. The entire MV apparatus, including the leaflets, chordae, papillary muscles and left ventricle (LV) were segmented and transformed into 3D digital models that were additionally modified to allow component-coupling to a flow loop. Digital 3D models were saved as Stereolithography (STL) files and then fabricated using a PolyJet printer (figure). MV elements were replicated using a blend of preselected 3D print materials. Each model was integrated into a flow loop and subjected to the pressurized flow conditions simulating the hemodynamic parameters of each patient. Qualitative and quantitative Doppler parameters of MR were assessed within this in vitro flow environment. **Results:** Six functional, patient-specific models of the MV apparatus and LV were created from 3D TEE data. Quantitative and qualitative assessments, including CW and color Doppler of modeled MR, showed remarkable agreement with those acquired in patients (figure). 3D echo surface images of the MV anatomy acquired for each model and patient-pair demonstrated appropriately similar surface reproduction. Color Doppler MR jet for each 3D model acquired in the flow loop showed excellent agreement with the clinical MR Doppler features. The Doppler velocity profile recorded across each MV model mimicked closely those recorded in patients. On average, the continuous wave Doppler peak velocity and ejection time for each model and patient differed by only 4% and 10%, respectively. **Conclusions:** We report, for the first time, that functional, multi-material, patient-specific models of the entire MV apparatus and LV can be replicated from clinical

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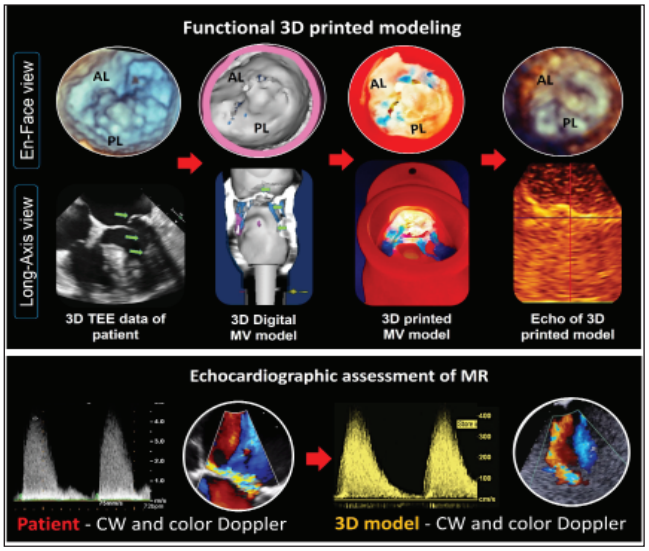
3D TEE data. When coupled to a flow loop tailored to reproduce LV flow and pressure curves, the clinical MR is also well simulated. Such models may be used for evaluation of catheter-based intervention such as MitraClip.



P1-110

Revolutionary Echocardiographic Analysis Approach for Congenital Mitral Valve Malformations

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Background: The mitral valve (MV) apparatus is complex. Congenital mitral valve malformations (CMVMs) constitute a wide spectrum of pathology and some are extremely rare. Successful treatment relies upon accurate preoperative assessment. Traditional methods of describing and classifying CMVMs lack specificity and scientificity, especially in terms of ultrasound diagnosis. **Methods:** We enrolled 458 patients who had congenital anatomic and functional malformations of the MV apparatus (mean age, 35.2 ± 22.5 years; male 49.1%) during 5 years period, each subject underwent 2D and/or RT3D transthoracic or transesophageal echocardiographic evaluation of CMVMs. MV apparatus characteristics were described and analyzed via a novel four-tiered echocardiographic analysis (FTEA) approach we created: (1) supravalvular region and annulus, (2) valvar leaflets and commissures, (3) chordae tendineae, and (4) papillary muscles. **Results:** Through 27, 5812 echocardiographic examinations, CMVMs were methodically studied in 458 (0.17%) patients. Of these, 19 (4.1%) had multi-tier malformations; and in 146 (32%), CVCMs were associated with other congenital cardiac malformations. Using a FTEA diagnostic method, CMVMs was distributed as follows: (1)the first tier (n=9; excessive supravalvular tissue, 4; annulus abnormities, 5 [overriding, 2; shifted, 2; bridging accessory tissue, 1]); (2) the second tier (n=436; lengthy, 213; underdeveloped, 38; loose, 65; clefts, 60; fibrotic, 18; contracture, 12; dual orifice, 7; bulging, 6; atretic, 5; accessory tissue, 4; fused cusps, 3; anomalously connected, 1; abnormal commissures, 4 [fused, 1; clefts, 3]); (3) the third tier (n=16; anomalously connected, 5; thickened/fused, 3; excessive, 2; shortened, 3; fibrotic, 2; accessory tissue, 1; straddling, 1); and (4) the fourth tier (n=16; abnormally located, 6; single, 5; absent, 2; asymmetric, 2; fibrotic, 1). **Conclusions:** Compared with traditional ultrasonic diagnosis method for CMVMs, detailed novel FTEA approach in a systematic and scientific manner clearly defines malformations of the MV apparatus, ensuring more accurate diagnostic imaging and prompt.

P1-112

Hemodynamic and Echocardiographic Changes Associated with Valvuloarterial Impedance Severity in Patients Undergoing Transcatheter Aortic Valve Replacement

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Background: Valvuloarterial impedance [Z(va)] measures the global hemodynamic load imposed on the left ventricle, incorporating afterload from both valvular and systemic levels. Previous studies suggest that a high Z(va) is associated with poorer outcomes in patients with aortic stenosis. Little is known about the significance of Z(va) in the setting of transcatheter aortic valve replacement (TAVR), particularly in respect to echocardiographic and hemodynamic characteristics associated with Z(va) severity. **Methods:** 199 consecutive patients with severe aortic stenosis who underwent TAVR were evaluated. Clinical, hemodynamic, and echocardiographic data were analyzed at baseline as well as immediately, 48 hours, and 30 days after TAVR. Patients were divided according to Z(va) severity (Low < 3.5, Med 3.5-4.5, and High > 4.5). **Results:** The 3 groups did not differ significantly in respect to baseline characteristics. Only patients with high baseline Z(va) had a significant mean Z(va) decrease post-TAVR that persisted at 30 days ($p = 0.0006$). Patients with high baseline Z(va) had a significant increase in stroke volume (SV) (19 mL, $p < 0.0001$), cardiac output (CO) (0.550 L/min, $p = 0.0172$) and ejection fraction (EF) (3.41%, $p < 0.0007$) immediately and 30 days post-TAVR. Conversely, patients with low Z(va) had a decrease in SV (10.04 mL, $p = 0.0280$), no change in CO ($p = 0.249$) and smaller increase in EF (2.678%, $p = 0.0088$). Systolic blood pressure lowered in the high Z(va) group and increased in the low Z(va) group, respectively (-1.36 vs +17.7 mmHg at 30 days, $p = 0.021$). Systemic arterial compliance increased in the high Z(va) group but decreased in the low Z(va) group, respectively (+0.18 vs -0.1 ml/mmHg at 30 days, $p = 0.005$). Amongst the three groups, baseline high Z(va) had lower rates of 30 day death ($p < 0.05$); other clinical outcomes were similar. **Conclusion:** When stratified by severity of Z(va), patients with severe aortic stenosis undergoing TAVR may have different hemodynamic changes. More favorable hemodynamic effects are observed post-TAVR in patients with higher baseline Z(va), as demonstrated by greater improvement in Z(va), SV, CO, EF, and arterial compliance. Patients with low Z(va) had a paradoxical increase in Z(va) with decrease in SV and arterial compliance, and had a higher rate of death at 30 days. Left ventricular afterload is not isolated to the aortic valve, but involves a global process. Our study suggests that TAVR is most beneficial in those with the highest Z(va), which estimates global afterload, and maybe a useful tool for patient selection and risk stratification

P1-113

Transcatheter Aortic Valve Replacement with Transthoracic Echocardiography is Associated with Reduced Hospital Length of Stay and Risk of Delirium Without an Increase in Paravalvular Regurgitation or Decrease in Survival

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Background: There is a gradual shift towards the use of TTE instead of TEE during TAVR. The valve team must weigh procedural risks with the improved resolution of TEE as compared to TTE. The aim of this study is to compare patient and echocardiographic outcomes in patients undergoing TEE- versus TTE-guided TAVR. **Methods:** Subjects undergoing TAVR at a single institution from 6/2008-7/2017 were retrospectively analyzed according to imaging modality. Demographic, pre-procedural and outcome variables were obtained and adjudicated using VARC2 criteria. Multivariate logistic regression, linear regression and Cox proportional hazards were used. **Results:** 676 subjects were included in the analysis. 368 (54.4%) underwent TEE and 308 (45.6%) TTE. Subjects undergoing TEE were older (81.8±8.8 vs. 79.9±10.1 $p<0.05$), had higher STS risk scores (8.6±4.7 vs. 5.7±3.5 $p<0.001$), and had higher rates of NYHA Class IV symptoms (24.7% vs. 2.9% $p<0.001$). Those undergoing TEE monitoring also had lower left ventricular ejection fraction (52.9±14.1 vs. 58.5±12.6 $p<0.001$) and aortic valve area (0.70±0.25 vs. 0.78±0.27 $p<0.001$). Those undergoing TTE guided TAVR were more likely to be performed via transfemoral route (99.4% vs. 70.7% $p<0.001$) and receive a third generation device (80.5% vs. 19.3% $p<0.001$). TTE-guidance was associated with higher device success rates (92.2% vs. 81.8% $p<0.001$) and a decreased risk of post-TAVR delirium (OR 0.38 95% CI 0.18-0.81 $p<0.05$). There was no increased risk of 30-day mortality, 1-year mortality or post-procedure respiratory failure. TTE guided TAVR was associated with a 1.2 day (95% CI 0.27-2.14 $p=0.01$) shorter hospitalization than TEE-guided TAVR. Subjects undergoing TEE-guided TAVR had higher rates of immediate post-procedure moderate or greater paravalvular or valvular aortic regurgitation than TTE. There was no difference in overall survival between the two groups (HR 0.79 (95% CI 0.48-1.31 $p=0.36$). **Conclusions:** With the expansion of TAVR to lower risk patients, TTE guided TAVR is now a viable option due to greater procedural experience and devices with less paravalvular regurgitation. This single-center experience shows that the use of TTE during TAVR results in decreased length of stay and rates of delirium without an increase in paravalvular regurgitation or decrease in survival.

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Table 1- Baseline and procedural characteristics of subjects undergoing TAVR			
	Overall (n= 676)	TEE (n=368)	TTE (n=308)
Age (years)*	81.0±9.5	81.8±8.8	79.9±10.1
Male	370 (54.9)	199 (54.1)	171 (55.9)
Non-white*	88 (13.0)	37 (10.1)	51 (16.6)
Obese	217 (32.1)	114 (31.0)	103 (33.4)
Underweight	21 (3.1)	13 (3.5)	8 (2.6)
NYHA III*	431 (63.8)	219 (59.5)	212 (68.8)
NYHA IV**	100 (14.8)	91 (24.7)	9 (2.9)
STS score**	7.3±4.4	8.6±4.7	5.7±3.5
Transfemoral access**	566 (83.7)	260 (70.7)	306 (99.4)
Balloon Expandable valve*	553 (81.8)	292 (79.3)	261 (84.7)
Third generation valve**	319 (47.2)	71 (19.3)	248 (80.5)
Pre-LVEF (%)**	55.5±13.7	52.9±14.1	58.5±12.6
Aortic Valve Peak Velocity (m/s)	4.4±2.2	4.3±2.1	4.4±2.3
Aortic Valve Peak Gradient (mmHg)	73.6±23.6	72.4±22.3	75.5±24.6
Aortic Valve Mean Gradient (mmHg)	43.2±14.6	42.2±13.7	44.1±15.3
Aortic Valve Area (cm^2)**	0.74±0.26	0.70±0.25	0.78±0.27
History of CAD**	540 (79.9)	321 (87.2)	219 (71.1)
History of A fib/Flutter	271 (40.1)	153 (41.6)	118 (38.3)
History of peripheral arterial disease**	178 (26.3)	123 (33.4)	55 (17.9)
History of CKD	242 (35.8)	139 (37.8)	103 (33.4)
Device Success**	585 (86.5)	301 (81.8)	284 (92.2)
Intra-procedure echo with ≥ moderate paravalvular or valvular AR**	50 (7.4)	41 (11.1)	9 (2.9)
Day 30 echo with ≥ moderate paravalvular or valvular AR**	49 (7.2)	38 (10.3)	11 (3.6)

Table 2- Unadjusted and Adjusted Endpoints of TTE vs TEE-guided TAVR		
	Unadjusted Odds Ratio	Adjusted Odds Ratio
30 Day Mortality	0.83 (0.41-1.67)	0.73 (0.23-2.84)
365 Day Mortality	0.37 (0.23-0.59)**	0.71 (0.37-1.35)
Delirium	0.23 (0.13-0.40)**	0.38 (0.13-0.81)*
Post procedure respiratory failure	0.29 (0.13-0.69)**	0.48 (0.16-1.5)

Adjusted for STS score, mean gradient, AVA, alternative access, valve generation and procedure success
**p<0.001
*p<0.05

P1-114

Mortality from Aortic Stenosis Across the Spectrum of Severity: Analysis of Big Data from the National Echo Database of Australia (NEDA)

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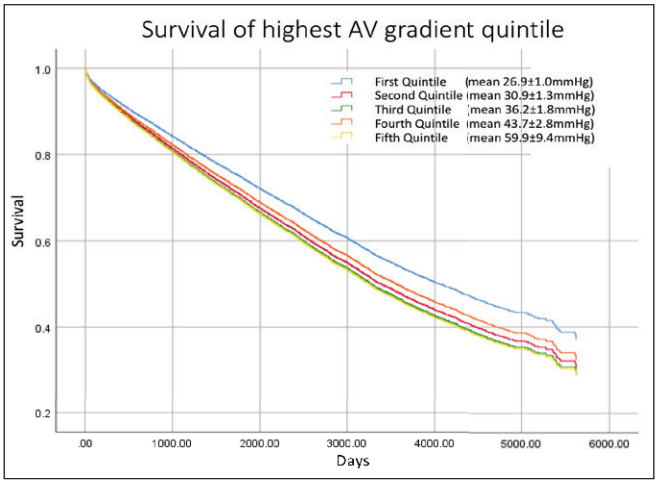
Background: Echocardiography (echo) is pivotal in evaluation of aortic valve gradients. We evaluated prognostic implications of the full spectrum of aortic stenosis severity in a large patient cohort, matched with mortality data. **Methods:** NEDA is a vendor-agnostic cloud-based database, containing echo measurement data (1997 -2017) from laboratories (N=10) across Australia (currently >530,000 Echos). Data linkage to the National Death Index (NDI) provided survival status on each induvial from the last recorded echo to a census date in October 2017. Data were available from 352,844 individuals comprising 186,820 men (60.8±18.0 yrs) and 166,024 women (60.9±19.2 yrs) with a mean follow up of 5.4 years per person and 63,142 fatal events. **Results:** Overall, a peak aortic valve velocity (AVvel) was recorded in 278,955 patients, demonstrating a J-shaped mortality pattern with highest age- and sex-adjusted risk profile in those individuals (n=52,010) in the upper quintile (> 1.8 m/s and mean aortic gradient of 13mmHg); HR=1.29 (95% CI 1.25-1.32, p<0.001) relative to the lowest quintile. 1- and 5-year mortality was 5.0% and 14.9% in the lowest vs 9.2 and 28.1% in the highest (p<0.0001) quintile, respectively. Those cases in the upper quintile were then further examined for survival against increasing gradients (n=44,340). After adjusting for age, gender and ejection fraction, the mortality risk plateaued at a threshold of a mean gradient ≥30.9±1.3mmHg (AVvel > 3.71±0.26m/s), with an adjusted HR=0.94(95% CI 0.82-1.08, p=0.4) compared with those in the upper quintile of that group (mean gradient 59.9±9.4mmHg, AVvel 4.96±0.47m/s). 1- and 5-year mortality profiles were equivalent for those with mean aortic pressure gradients 20-30mmHg (10.9%, 32.6% respectively), 30-40mmHg (11.8%, 33.0%) and >40mmHg (13.7%, 34.5%). **Conclusion:** Aortic stenosis is associated with significant mortality across the spectrum of severity, including mild disease. There is no discernible difference in survival between "moderate" and "severe" aortic stenosis.



P1-115

The Association of Echocardiographic Surveillance of Valvular Heart Disease with Different Sociodemographic Groups

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Background: Clinical outcomes of patients with valvular heart disease vary across sociodemographic groups. Differences in frequency of trans-thoracic echocardiogram (TTE) surveillance may contribute to differences in clinical outcomes. We hypothesized that sociodemographic factors were associated with appropriately timed surveillance imaging for aortic stenosis (AS), mitral regurgitation (MR), and aortic insufficiency (AI). **Methods:** We linked records of all TTEs from 2001-2016 ordered at a large echocardiographic laboratory to demographic patient data and selected patients who were likely to have had TTEs performed for surveillance of AS, AI, or MR. Time intervals were calculated between sequential TTEs for a given patient, and the binary outcome variable was defined as receipt of a TTE within the guideline-recommended interval for the most severe valve disease noted in the index TTE. Logistic regression was used to determine the association of race/ethnicity, gender, and insurance status with the likelihood of receiving a TTE within the appropriate interval. **Results:** Our study cohort comprised 130,725 TTEs, representing 42,289 unique patients. Non-Hispanic black patients were significantly less likely to receive appropriate TTE surveillance than white patients, with an odds ratio (OR) of 0.74 (95% CI 0.66-0.83; p <0.0001), as were women OR 0.90 (95% CI 0.86-0.95; p <0.0001) when compared to men. Medicaid patients were also less likely to receive appropriate TTE surveillance than Medicare patients (OR 0.85; 0.75-0.96; p = 0.0095). In addition, older patients were also significantly less likely to receive appropriate TTE surveillance when compared to younger patients with OR 0.45 (95% CI 0.31-0.66; p <0.0001) for those 61-70 years old, OR 0.39 (95% CI 0.26-0.57; p < 0.0001) for those 71-80 years old, and OR 0.31 (95% CI 0.21-31; p<0.0001) for those 81-90 years old when compared to those 18-20 years old. **Conclusions:** Older, black, female patients, as well as patients on Medicaid, are less likely to receive appropriate TTE surveillance for valvular disease. These results provide targets for care improvement strategies and suggest the need for further investigation into the clinical consequences of delayed surveillance for specific sociodemographic groups.

P1-116

Flow Reversal in the Aorta in the Absence of Aortic Regurgitation in Patients Undergoing TAVR

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Background: Flow reversal in the descending thoracic aorta (DTA) is incorporated into both American Society of Echocardiography (ASE) and European Association of Echocardiography (EAE) guidelines for the echocardiographic assessment of native valve aortic regurgitation (AR). Prominent holodiastolic reversal (ASE) or holodiastolic flow reversal with an end-diastolic velocity ≥ 20 cm/s (EAE) support the diagnosis of severe AR as does flow reversal in the abdominal aorta (AAo). These approaches have been extrapolated to the assessment of AR in elderly patients undergoing transcatheter aortic valve replacement (TAVR) although guidelines recognize that reduced aortic compliance may limit the specificity of these findings. We hypothesized that aortic flow reversal may be false positively present in patients undergoing TAVR in the absence of AR, impacting its use in assessing post TAVR AR. **Methods:** We prospectively evaluated the prevalence and degree of flow reversal in the DTA and AAo in 101 consecutive pts (71 following exclusions for inadequate DTA flow signal) with severe aortic stenosis and no more than

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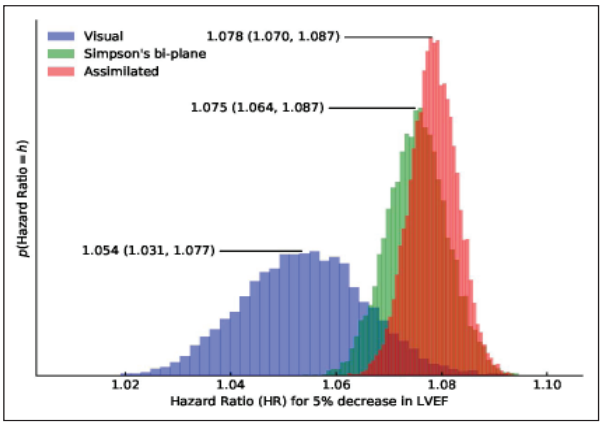
trace AR undergoing TAVR screening. DTA PW Doppler flow was recorded just distal to the left subclavian from a suprasternal view with AAo flow recorded from a subcostal view, aligning the echo beam with flow. Filters were optimized to detect low velocities with flow reversal defined as unidirectional flow ≥10cm/s. The degree of flow reversal was quantitated by its duration (%diastole) and the presence of end-diastolic velocity ≥ 20 cm/s. All measurements were averaged over 3 beats during off-line review. Analyzable and adequately aligned AAo flow signals were available in 28/71 subjects. **Results:** Values presented as mean±SD. Age was 82±9y, 52% male. BP was 126±17/69±9 mmHg with 11(16%) pts having BP ≥140/90. Some degree of flow reversal was present in the DTA and AAo in 71 (95%) and 12 (42%) respectively with flow reversal occupying 42±25% and 25% ±25% diastole respectively. Holodiastolic regurgitation in the DTA and AAo occurred in 42 and 12% pts respectively. Holodiastolic flow reversal with end-diastolic velocity ≥20cm/sec in the DTA and AAo occurred in 15% and 5% pts respectively. **Conclusions:** Flow reversal in the DTA and, less commonly, the AAo is present in patients undergoing TAVR even in the absence of AR. If this marker is to be used in this elderly population, a baseline determination of its presence before TAVR, when there is no significant AR, must be performed. It should be used in the post TAVR assessment of AR only if it is absent or of short duration at baseline.

P1-117

Assimilated LVEF: Combining Human Intuition with Machine Measurement for Sharper Estimates of Left Ventricular Ejection Fraction and Stronger Association with Outcomes

Thomas McAndrew[1], Bjorn Redfors[1], Aaron Crowley[1], Yiran Zhang[1], Maria C. Alu[2], Matthew T. Finn[2], Ariel Furer[1], Shmuel Chen[1], Geraldine Ong[3], Dan Burkhoff[1], Ori Ben-Yehuda[1], Wael A. Jaber[4], Rebecca T. Hahn[2], Martin B. Leon[2,1]. [1]Cardiovascular Research Foundation, New York, NY; [2]Columbia University Medical Center, New York, NY; [3]Quebec Heart & Lung Institute, Quebec, QC, Canada; [4]Cleveland Clinic, Cleveland, OH

Background: Variability in LVEF measurement can complicate reproducing statistical findings from one analysis to another. A trained cardiologist's visual estimate of LVEF can manage inconsistent image quality and may result in clearer estimates than the more sensitive Simpson's biplane method. In this analysis, we sought to reduce measurement error by fusing the cardiologist's visual estimate of LVEF with Simpson's biplane method. We hypothesize this assimilated LVEF will better correlate with clinical outcomes. **Methods:** We studied patients from the PARTNER-2A Trial, an intermediate risk cohort with aortic stenosis treated with bioprosthetic aortic valves, who have both visual and Simpson's biplane estimates of LVEF analyzed by a single core lab. We apply Bayesian techniques to average a patient's visual LVEF and Simpson's LVEF measurements with weights related to their respective precision to estimate a patient's true LVEF. This assimilated LVEF measurement LVEF draws accuracy from Simpson's LVEF and consistency from the visual LVEF, reducing measurement error. **Results:** Assimilating the cardiologist's visual estimate with Simpson's biplane estimate, we can reduce variability by 9.98% in patients with visual LVEF < 35%, by 8.89% in patients between 35% and 50%, and by 11.72% in patients above 50%. After accounting for LVEF's measurement error, we find a clearer association (compared to Simpson's biplane) between diminished LVEF and an increased rate of 1 year death, rehospitalization, and major stroke. The assimilated LVEF's hazard ratio relates decreasing LVEF and increasing hazards of 1-year death, stroke, and rehospitalization more confidently than Simpson's or visually estimated LVEF (**FIGURE**). We find a 5% increase in assimilated LVEF corresponds to a HR (95% credible interval) of 1.078 (1.070,1.087) versus 1.075 (1.064, 1.087) for 5% increase in Simpson's LVEF and 1.054 (1.031, 1.077) for 5% increase in visual LVEF. The assimilated LVEF's smaller credible interval represents a more certain and reproducible relationship between LVEF and clinical outcomes. **Conclusions:** Combining visual estimates and machine calculation of LVEF, we reduce reproducibility errors in LVEF measurement and improve the association between LVEF and a composite of death, stroke, and rehospitalization at 1 year.



P1-118

Echocardiographic Indices of Right Ventricular Function 24-hours post MitraClip Repair

Sati Patel, Aaron M. Wolfson, Jina Sohn, Vivian Y. Mo, Ray V. Matthews, David M. Shavelle, Andrew J. Yoon. University of Southern California, Los Angeles, CA

Background: Percutaneous mitral valve repair (PMVR) is a safe and effective alternative to surgery in individuals with severe mitral regurgitation (MR) and high surgical risk. Invasive methods such as cardiac catheterization or transesophageal echocardiogram immediately post PMVR are generally used for evaluating procedural success. Transthoracic echocardiography (TTE) allows for a non-invasive evaluation of wake-state hemodynamics. Post PMVR indices of right ventricular (RV) function on TTE are of particular interest as they bear prognostic relevance and are markers of procedural success. No prior study has evaluated these RV indices by TTE performed 1-day post procedure. In this retrospective study, we evaluated TTEs 1-day post PMVR for the presence, or lack thereof, of RV functional changes in relation to procedural success or failure. **Methods:** TTEs of 36 consecutive patients with severe, degenerative MR at a single institution were reviewed pre PMVR and 1-day post PMVR. Procedural success was defined as post procedural MR grade of ≤2+ (success) or >2+ (failure). Means of echocardiographic indices were compared using paired and independent t-tests. **Results:** 28 patients had procedural success, and 8 patients had procedural non-success. In successful PMVR, post procedural pulmonary velocity acceleration time was significantly increased (0.090 vs 0.071 s, p=0.034). There were also significant post PMVR decreases in both mean left ventricular (LV) septal e' velocity (5.79 vs 4.38 cm/s, p=0.007) and LV lateral e' velocity (9.06 vs 5.39 cm/s, p= 0.002) in successful procedures. Between groups, post PMVR tricuspid lateral annular systolic velocity (S') was significantly different (10.3 cm/s in successful vs 6.2 cm/s in unsuccessful, p=0.045). Additionally, post PMVR RV ejection time decreased in procedural success compared to non-success (-0.021s vs. +0.051s, p=0.034). **Conclusion:** Significant changes in TTE derived indices of RV function were seen as early as 1-day post PMVR. Our study suggests there are immediate hemodynamic consequences following procedural success or failure on RV function. Further studies may indicate the long-term prognostic value of these post-procedural RV indices.

	Successful PMVR			Unsuccessful PMVR			
	Pre (n=28)	Post	p value	Pre (n=8)	Post	p value	Post PMVR comparison (p value)*
LV Septal E' (cm/s)	5.79 ± 2.10	4.38 ± 1.78	0.007	5.8 ± 3.07	5.15 ±1.25	NS	NS
LV Lateral E' (cm/s)	9.06 ± 3.59	5.39 ± 2.40	0.002	11.11 ± 3.90	8.78 ± 2.56	NS	0.05
PVAT (ms)	0.07 ± 0.03	0.09 ± 0.03	0.016	0.07 ± 0.03	0.06 ± 0.02	NS	NS
RV S' (cm/s)	10.17± 2.89	10.29 ± 2.12	NS	5.85 ± 2.51	6.18 ± 2.41	NS	0.045
RV Isovolemic acceleration (cm/s²)	245.3 ± 237.80	299.39 ± 222.23	NS	266.9 ± 226	218.08 ±84.70	NS	NS
Mean pulmonary arterial pressure	57.6 ± 12.14	64.13 ± 6.61	NS	63.3 ± 3.69	69.5 ± 4.15	NS	NS
RV Fractional Area Change (%)	0.34 ± 0.18	0.36 ± 0.11	NS	0.32 ± 0.14	0.37 ± 0.05	NS	NS
** Comparison of post procedural indices in successful vs unsuccessful groups*							
NS- non significant							

P1-119

Prosthesis-to-LVOT Index: An Echocardiographic Predictor of Pacemaker Implantation After Transcatheter Aortic Valve Replacement

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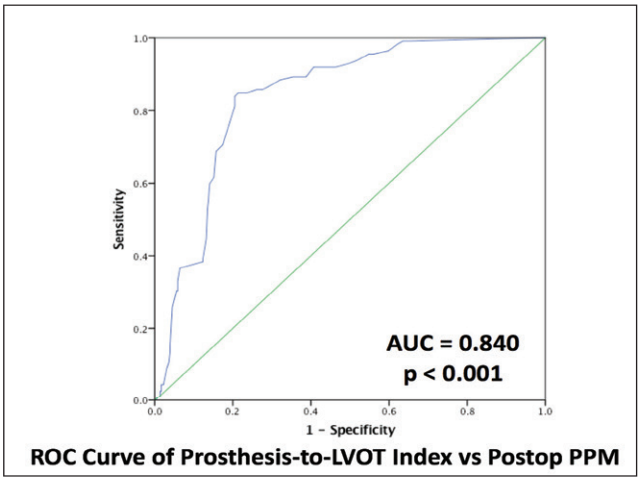
Background: Conduction abnormalities leading to permanent pacemaker (PPM) implantation are among the most common complications following transcatheter aortic valve replacement (TAVR). We hypothesized that a larger implanted prosthetic valve size relative to the left ventricular outflow tract (LVOT) diameter leads to greater compression of the cardiac conduction system. We aim to assess whether the ratio between the prosthetic valve size and LVOT diameter can aid in identifying patients at risk for PPM implantation after TAVR. **Methods:** We retrospectively reviewed 392 out of 508 consecutive patients who underwent TAVR at our institution from 2014 to 2016. We excluded patients who had pre-existing pacemakers and who underwent valve-in-valve procedures. Prosthesis-to-LVOT index was calculated as [valve size/LVOT diameter]. LVOT diameter was measured from the preoperative transthoracic echocardiogram. **Results:** A total of 98/392 patients (25%) required PPM implantation after TAVR. The most common indication for PPM was complete heart block (53/98, 54.08%). Using receiver operating characteristics (ROC) curve analysis, a prosthesis-to-LVOT index of 1.30 was found to be a strong predictor of PPM implantation (sensitivity = 83.9%, specificity = 79.5%, AUC = 0.840, p < 0.001). On multivariate analysis (adjusting for pre-

existing conduction abnormalities, valve type and access), prosthesis-to-LVOT index remained a strong, independent predictor of PPM implantation post-TAVR (adjusted odds ratio 5.22, 95% CI 3.74 - 7.27, p < 0.001). **Conclusions:** An elevated prosthesis-to-LVOT index (>1.30) is a useful marker for predicting PPM implantation following TAVR. Future studies evaluating the role of this index in preoperative risk stratification (selection of valve size, temporary/permanent pacing requirement) for TAVR are needed.



ROC Curve of Prosthesis-to-LVOT Index vs Postop PPM

P1-120

Left Cardiac Chambers Longitudinal Strain Differences Between Diastolic Dysfunction Grades in Patients with Severe Aortic Stenosis Before and 1 Year after Transcatheter Aortic Valve Replacement

Diego Medvedofsky[1], Tatsuya Miyoshi[1], Edward Koifman[2], Toby Rogers[2], Gai Jiaxiang[2], Itsik Ben-Dor[2], Lowell Satler[2], Rebecca Torguson[2], Ron Waksman[2], Federico M. Asch[1]. [1]MedStar Health Research Institute, Washington, DC; [2]MedStar Washington Hospital Center, Washington, DC

Background: LA strain is an emerging parameter proven to correlate with diastolic function. Left ventricular and atrial (LV, LA) strain detect subtle changes in chamber function. We aimed to assess LV and LA peak longitudinal strain (LS) according to diastolic dysfunction (DD) grades among patients with severe aortic stenosis (AS) undergoing transcatheter aortic valve replacement (TAVR) and their change 1-year after the procedure. **Methods:** We analyzed consecutive patients with severe AS that underwent TAVR between 2007-2014. Patients were included if echocardiograms in sinus rhythm pre- and 1-year post-procedure were available. Patients with pacemaker were excluded. DD grading was determined according to 2016 American Society of Echocardiography guidelines (grades I, indeterminate I-II, II and III). LV Global LS derived from speckled tracking was measured in 2-, 3- and 4-chamber views, while LA LS was measured in 4-chamber view (TOMTEC). Changes in LV and LA LS from baseline to 1-year post TAVR (LA and LV) were evaluated for each DD grade. **Results:** 154 patients were included (82±9 years old, 41% males, LV ejection fraction 60±10%). LV and LA LS worsened as DD grade increased (p<0.01), both pre and post TAVR (Table rows). Additionally, significant improvements for both LV and LA LS were seen at 1-year post-TAVR (columns) compared to pre-TAVR, except for grade III DD (p=NS). **Conclusions:** In patients with severe AS undergoing TAVR, baseline LV and LA LS worsened in parallel to DD grading. At 1-year post procedure, LA and LV LS improved among patients with baseline DD grades I, II and indeterminate. Grade III DD improvement failed to reach significance, but this could be related to the small sample size. LA LS is a single non-invasive echocardiographic parameter that should be considered as part of the DD guidelines algorithm and helps understand the remodeling process of left cardiac chambers 1-year post-TAVR.

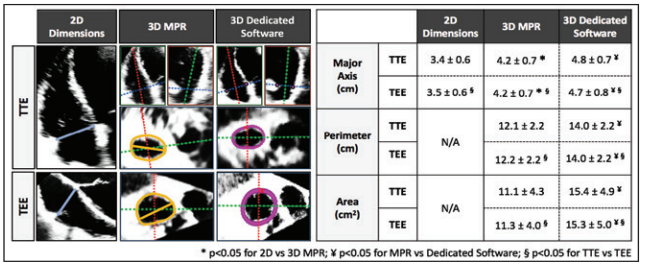
DD grades		I	Indeterminate I-II	II	III	p-value between DD grades
Patients at baseline (%)		26	11	55	8	
LV LS (%)	Pre-TAVR	-22.7 ± 3.7	-21.8 ± 4.6	-20.4 ± 4.3	-16.0 ± 3.0	<0.01
	Post-TAVR	-24.2 ± 3.5	-23.7 ± 4.1	-22.4 ± 3.5	-18.2 ± 5.1	<0.01
	p-value Pre vs Post	<0.01	<0.01	<0.01	0.18	
LA LS (%)	Pre-TAVR	22.1 ± 4.6	22.8 ± 6.2	18.4 ± 5.0	14.8 ± 3.0	<0.01
	Post-TAVR	24.0 ± 4.2	24.8 ± 5.8	21.2 ± 5.7	18.3 ± 7.0	<0.01
	p-value Pre vs Post	<0.01	0.05	<0.01	0.19	

P1-121

Echocardiographic Assessment of the Tricuspid Annulus: Does Measurement Methodology Matter?

Valentina Volpato[1], Megan Yamat[1], Federico Veronesi[1], Lynn Weinert[1], Gloria Tamborini[2], Manuela Muratori[2], Laura Fusini[2], Mauro Pepi[2], Victor Mor-Avi[1], Roberto M. Lang[1], Karima Addetia[1]. [1]University of Chicago, Chicago, IL; [2]Centro Cardiologico Monzino, Milan, Italy

Background: Accurate measurement of tricuspid annular (TA) dimensions is important for surgical decision-making in patients undergoing mitral valve surgery. Current guidelines recommend that TA measurements be performed on 2D transthoracic echocardiography (TTE). We hypothesized that: (1) 2D TTE measurements would be different from those obtained with 2D transesophageal echocardiography (TEE) because different cross-sections of the oval shaped annulus are measured, and (2) 3D echocardiographic TA measurements would be larger than the 2D measurements and would be similar irrespective of the imaging approach. **Methods:** We studied 50 patients in regular rhythm who underwent clinically indicated TTE and TTE on the same day. 2D TA diameter was measured from the right ventricular focused (RVF) view on TTE and from the mid-esophageal 4-chamber view (ME-4CH) on TEE. 3D full-volume datasets were acquired and analyzed using both multi-planar reconstruction (MPR) and dedicated tricuspid valve software (DS). 3D TA measurements included major and minor axes, perimeter and areas. We performed three comparisons of TA dimensions measured by different techniques (Figure): (1) 2D TTE vs 2D TEE, (2) 2D vs 3D based on MPR for both TTE and TEE, and (3) 3D with MPR vs 3D measurements using DS which takes into account the saddle shape of the annulus. **Results:** 2D TEE measurements of TA dimensions were significantly larger than those obtained with 2D TTE (Table). The 3D major axis measured with both MPR and DS was significantly larger than that measured by 2D TTE and TEE (p<0.001). There were no differences in TA dimensions between 3D TTE and 3D TEE, irrespective of whether MPR or DS was used. All parameters measured with DS were significantly larger than those measured with MPR. **Conclusion:** Our findings highlight the need for methodology that takes into account the 3D geometry of the tricuspid annulus, which cannot be accurately assessed on a single 2D plane, as reflected by the differences between the 2D TTE and 2D TEE measurements, as well as 2D and 3D measurements. Importantly, 3D TTE approach can be used for TA measurements since no differences were found between 3D TTE and TEE. However, our results indicate that an approach that takes into account the non-planarity of the tricuspid annulus may be advantageous for 3D analysis.



		2D Dimensions	3D MPR	3D Dedicated Software
Major Axis (cm)	TTE	3.4 ± 0.6	4.2 ± 0.7 *	4.8 ± 0.7 ¥
	TEE	3.5 ± 0.6 §	4.2 ± 0.7 * §	4.7 ± 0.8 ¥ §
Perimeter (cm)	TTE	N/A	12.1 ± 2.2	14.0 ± 2.2 ¥
	TEE		12.2 ± 2.2 §	14.0 ± 2.2 ¥ §
Area (cm^2)	TTE	N/A	11.1 ± 4.3	15.4 ± 4.9 ¥
	TEE		11.3 ± 4.0 §	15.3 ± 5.0 ¥ §

* p<0.05 for 2D vs 3D MPR; ¥ p<0.05 for MPR vs Dedicated Software; § p<0.05 for TTE vs TEE

P1-122

Elevated Left Atrial Pressure Is Associated With Persistent Iatrogenic Atrial Septal Defect After Percutaneous Mitral Valve Repair With MitraClip

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Background: Percutaneous mitral valve repair with MitraClip requires interatrial transseptal puncture to access the left atrium (LA) and the resulting iatrogenic atrial septal defect (iASD) by the 24Fr steerable guide catheter is not routinely closed and not uncommon after MitraClip procedure. Persistent iASD after MitraClip procedure have been investigated in some studies. However, hemodynamic determinants of iASD remains unknown. We sought to investigate these determinants of iASD after MitraClip procedure. **Methods:** A total of 131 patients with grades 3 to 4+ mitral regurgitation who underwent MitraClip procedure and completed immediate invasive hemodynamic measurement, baseline, 1-month and 12-month of transthoracic echocardiography (TTE) follow-up were retrospectively reviewed. **Results:** TTE at 1-month showed persistent iASD in 74 (56.5%) patients (1M-iASD). After we excluded 5 patients from patients with 1M-iASD, 24 (34.8%) patients among patients with 1M-iASD had persistent iASD at 12-month (12M-iASD, Figure 1). Mean LA pressure post-MitraClip was significantly higher in patients with 1M-iASD than patients without 1M-iASD (17.1 ± 6.2 mm Hg vs. 14.6 ± 5.4 mm Hg, p = 0.01, Figure 2-A). Mean LA pressure post-MitraClip was significantly higher in patients with 12M-iASD than patients without 12M-iASD (19.0 ± 6.2 mm Hg vs. 15.8 ± 5.5 mm Hg, p = 0.04, Figure 2-B). Univariate regression analysis showed that mean LA pressure post-MitraClip was significantly associated with persistent iASD at 12-month in patients with 1M-iASD (odds ratio 1.10, 95% confidence interval 1.01-1.25,

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p = 0.03). Patients with 12M-iASD did not significantly differ from patients without 12M-iASD in terms of right heart enlargement, estimated systolic pulmonary artery pressure, New York Heart Association functional class and brain natriuretic peptide at 12-month. **Conclusions:** The elevated LA pressure after MitraClip procedure predicted persistent iASD.

Figure 1. Examples of persistent iASD at 1-month and 12-month

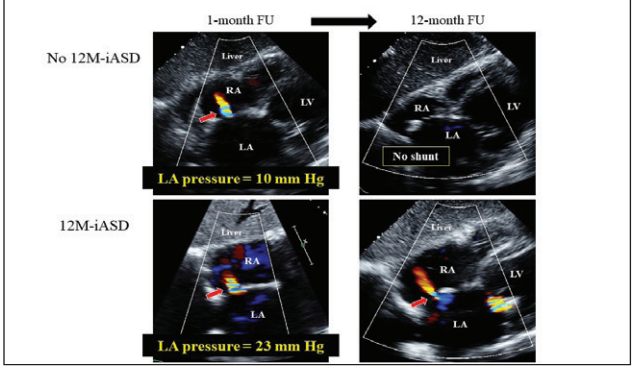
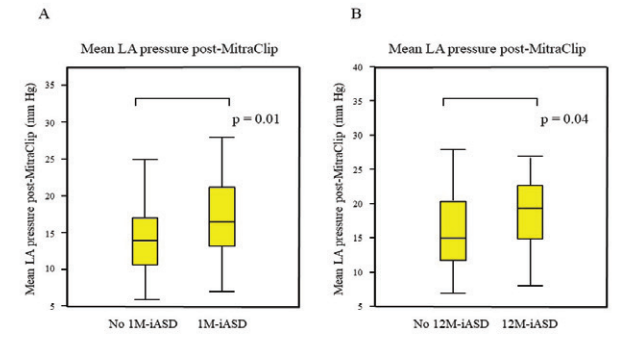


Figure 2. Mean LA pressure post-MitraClip between the two groups



P1-123

The Impact of Energy Loss Index on the Left Ventricular Mass After Transcatheter Aortic Valve Replacement: A Comparison Between Energy Loss Index and Effective Orifice Area Index

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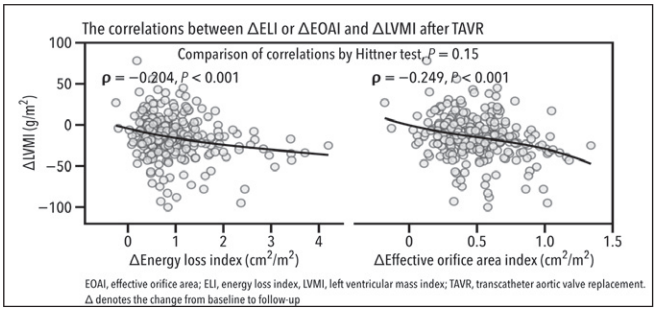
Background: Aortic valve stenosis elicits left ventricular hypertrophy due to pressure overload. Excessive increased left ventricular mass is associated with poor survival in significant aortic stenosis. Left ventricular mass reduction is observed after transcatheter aortic valve replacement (TAVR). Energy loss index (ELI) has been proposed as a functional index to estimate energy loss occurred at the ascending aorta. ELI provides the additional information about the severity of aortic stenosis to the conventional index such as effective orifice area index (EOAI). We presumed that the improvement of ELI should be related to the left ventricular mass reduction after TAVR. We investigated the relation between the improvement of ELI or EOAI and left ventricular mass index (LVMI) reduction after TAVR. **Methods:** Transthoracic echocardiography at baseline and follow-up (> 90 days after TAVR) were reviewed. Both of ELI at baseline and follow-up were found in 280 patients who underwent TAVR from January 2011 to December 2015. Effective orifice area was calculated by the continuous equation and indexed to body surface area as EOAI. ELI was calculated by the following equation: AVA×Aa/(Aa-AVA)/m^2 in which AVA = aortic valve area, Aa = aortic area at the level of the sinotubular junction, and m^2 = body surface area. LVMI was calculated by Cube formula and indexed to body surface area. Spearman's correlation coefficient was used to see the relation between the change of (Δ: change from baseline to follow-up) ELI or ΔEOAI and ΔLVMI. Hittner test was used to compare correlations. **Results:** There were significant correlations between ΔELI and ΔLVMI (ρ = -0.204, $P < 0.001$) and that of ΔEOAI and ΔLVMI (ρ = -0.249, $P < 0.001$) (Figure). There was no significant difference between the correlation between ΔELI and ΔLVMI and that of ΔEOAI and ΔLVMI (Hittner test, $P = 0.15$). **Conclusions:** ΔELI, as well as ΔEOAI, was significantly correlated with ΔLVMI after TAVR.



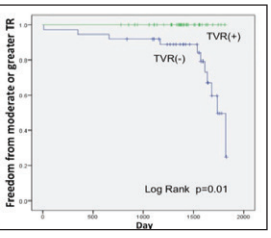
P1-124

Concomitant Tricuspid Valve Repair for Mild Tricuspid Regurgitation Suppress Progression of Tricuspid Regurgitation in Patients in Long-Term Follow-up Period

Kohko Kanazawa[1], Masumi Iwai-Takano[2], Goro Ishida[1], Yoshiyuki Kamiyama[1], Nobuo Komatsu[1], Hiroto Takeda[1], Koki Takahashi[3], Masahiro Tanji[3], Tetsuya Ohira[4]. [1]Ohta-Nishinouchi General Hospital, Division of Cardiology, Koriyama, Japan; [2]Fukushima Medical University, Intensive Care Unit, Fukushima, Japan; [3]Ohta-Nishinouchi General Hospital, Division of Cardiovascular Surgery, Koriyama, Japan; [4]Fukushima Medical University, Department of Epidemiology, Fukushima, Japan

Purpose: We examined whether concomitant tricuspid valve repair (TVR) for mild tricuspid regurgitation (TR) in patients with left sided valvular disease suppress the progression of TR in long-term period. **Methods:** We enrolled 74 consecutive patients who were performed surgical treatment for mitral and/or aortic valve disease with mild TR. All patients were divided into two groups depending on the treatment with TVR or without TVR, i.e., TVR(+) group (n=37) and TVR(-) group (n=37). In the follow-up period (3.9±0.7 years), we compared the grade of TR and cardiac events between the two groups. **Results:** There were no differences in age (TVR(+) group vs TVR(-) group: 63±13 vs 61±15 years), gender, operation time, LVEF (58±15 vs 59±14%) between the two groups at baseline. There were no differences in cardiac events (n) [TVR(+) group vs TVR(-) group; heart failure: 2 vs 1, infective endocarditis: 0 vs 0 and newly device implantation: 5 vs 7]. In the follow-up period, there were 11 patients with moderate TR (29.7%) in the TVR(-) group. In contrast, there was no moderate TR in the TVR(+) group. By Kaplan-Meier analysis, freedom from moderate or greater TR was significantly different in the two groups (p=0.01). **Conclusion:** Concomitant TVR for mild TR suppress the progression of TR in patients with left sided valvular disease in long-term follow-up period.

	pre		post		P value
TVR(−)	none	n = 1	none	n = 1	< 0.01
	trivial	n = 14	trivial	n = 13	
	mild	n = 22	mild	n = 12	
	moderate	n = 0	moderate	n = 11	
TVR(+)	none	n = 0	none	n = 5	< 0.01
	trivial	n = 4	trivial	n = 20	
	mild	n = 33	mild	n = 12	
	moderate	n = 0	moderate	n = 0	



P1-125

Influence of Metabolic Syndrome and its Components on Disease Progression and Outcomes in Aortic Stenosis in Patients with Bicuspid Aortic Valves

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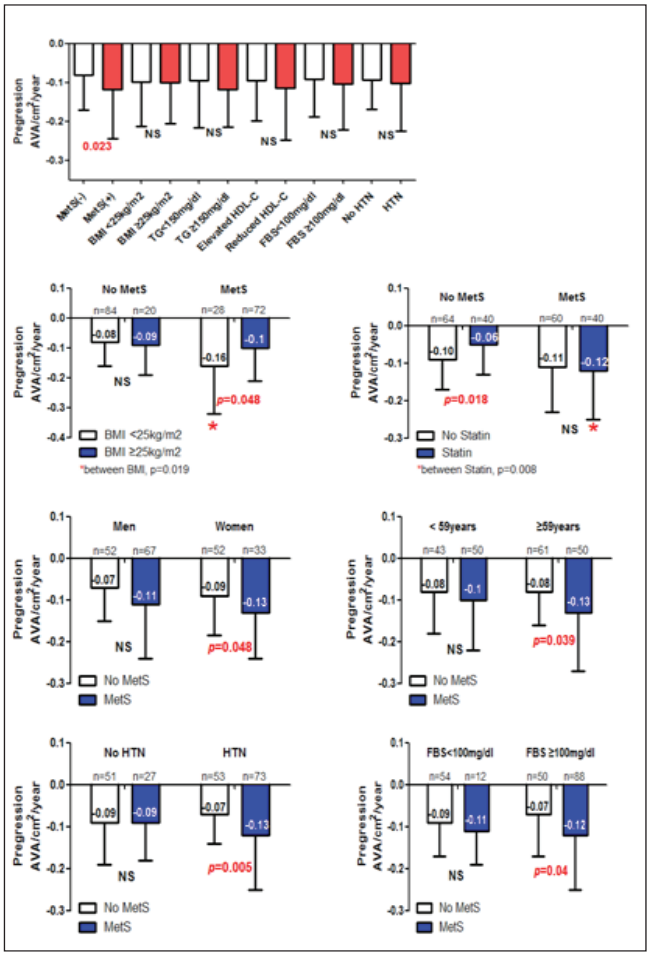
Background: Metabolic syndrome (MS) is known to be associated with either a faster disease progression of degenerative aortic stenosis (AS) and accelerated degeneration of bioprosthetic valves owing to its atherogenic features. However, the influence of MS on AS progression and clinical outcomes in patients with bicuspid aortic valve (BAV) has not been studied. **Methods:** A total of 1,640 patients with BAVs were identified at two tertiary centers in Korea from 2003 to 2016. Among them, 204 patients (age 59±10 years, 139 men) with moderate AS were ultimately included in this study. Of these patients, 100 (49%) patients had MS defined modified criteria proposed by the National Cholesterol Education Program Adult Treatment Panel III. Hemodynamic progression of AS was assessed by the measurement of the annualized decreased in aortic valve area (AVA) during follow-up period, which averaged for 41 months. The clinical outcome was the composite of aortic valve replacement or death. **Results:** MS had significant effect on the progression of AS in patients(-0.08±0.08 vs.-0.12±0.12, p=0.023). However,

its components of MS was not associated with progression of AS, respectively. Among the 2 groups separated according to the presence of absence of obesity in patients with or without MS, progression rate of stenosis was increased significantly in the slimmer patients with MS. Furthermore, statin therapy had significant effect on the progression of the disease in patients without metabolic syndrome However, statin therapy was not able to slow valve progression in patients with metabolic syndromeHowever, statin therapy was not able to slow valve progression in patients with MS. Among the 2 groups separated according to the presence of absence of MS, women with MS, patients with advanced age, hypertension with MS, and higher glucose with MS had a faster progression of AS than those without MS, respectively. During follow-up, end points were observed including 61 AVR and 10 deaths. However, the MS was not related with the clinical outcomes. **Conclusions:** MS was associated with a faster disease progression in patients with BAV AS. Women, advanced age, hypertension, and higher glucose with MS, respectively, were linked to progression of BAV AS. MS was not related with adverse clinical outcomes in patients with BAV AS.



P1-126

The "Double Loaded" LV: High Prevalence of Hypertensive LVH Preceding the Development of Severe Aortic Stenosis

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Background: It is traditionally assumed that left ventricular hypertrophy (LVH) in aortic stenosis (AS) is a compensatory adaptation to chronic outflow obstruction. However the advent of TAVR has stimulated more focus on AS in older patients, most of whom have antecedent hypertension (HTN). Accordingly our aim was to investigate the interaction between HTN and AS on LV remodeling in contemporary practice. **Methods:** We serially studied 60 consecutive patients with AV peak velocity (PV) >2.5 m/s on their initial echo and a PV of >3.5 m/s on a subsequent study performed at least 5 years later. Patients' demographics and clinical information were collected. Peak intraventricular pressure (IVP, mmHg) was defined as the sum of systolic arterial pressure and peak intraventricular gradient. Data were analyzed using descriptive statistics, paired- samples T test, and linear correlation. **Results:** Of our sample, 56% were women with mean age of 80±10 years. The average interval between the two echo studies was 58±22 months. As expected, wall thickness, LV mass, and relative wall thickness increased over time, in parallel with increasing IVP. There was no correlation between change in LV mass index (LVMi, g/m^2) and peak IVP, PV or AV MG. However change in LVMi did correlate inversely with initial LVM (r= -0.1). **Conclusions:** 1. Most patients seen in our practice with severe AS have antecedent hypertension and hypertrophic remodeling of the LV *before severe AS develops.* 2. Over time, such remodeling in these 'double loaded' hearts worsens in parallel with worsening severity of AS. 3. Remodeling in these patients features increasing concentric remodeling of the LV, rather than LV dilation. 4. Accordingly, we speculate that regression of LVH to normal will not be effected by AVR because LVH preceded hemodynamically severe AS. 5. The clinical import of these findings is that blood pressure control might be of equal importance in preventing and reversing hypertrophic remodeling in AS in contemporary practice.

Table 1: Echocardiographic measurements of baseline and subsequent studies

	LVIDd (mm)	PWT (mm)	RWT(mm)	LVMi (g/m^2)	EF (%)	PV (m/s)	AV MG (mmHg)	IVP (mmHg)
Baseline Echo	45.0±6.7	11.1±2.0	0.5±0.1	90.8±22.5	61.2±7.9	3.0±7.5	23.6±11.5	164.6±21.9
Follow up Echo	46.5±6.5	11.6±2.8	0.5±0.1	111.5±36.4	59.2±10.4	4.3±6.7	47.7±16.3	180.9±27.4
p-value	0.13	0.2	0.17	0.00	0.09	0.00	0.00	0.00

Comparison was by paired T-test; * p<0.05

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Mean Transmitral Flow Rate in Patients with Degenerative Mitral Stenosis

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Background: Degenerative mitral stenosis (DMS) is chronic non-inflammatory degeneration and calcification of the mitral valve. Current guidelines define severe mitral stenosis (MS) as mitral valve area (MVA) ≤1.5 cm^2 and very severe MS as MVA ≤1 cm^2. Echocardiographic tools used to define stenosis severity have been validated in rheumatic mitral stenosis (RMS), but not in DMS. We previously showed that mean transmitral gradients do not correlate well with stenosis severity in DMS. As mean transvalvular gradient is directly proportional to the square of transvalvular flow, a difference in flow may explain our previous observations. In the present study, we sought to: a) evaluate the differences in transmitral flow rates in DMS and RMS, b) define the relationship between transmitral flow rate and MVA according to stenosis severity, and c) investigate the relationship between mean gradient and MVA in DMS and low left ventricular (LV) stroke volume (defined as ≤35ml/m^2). **Methods:** 64 patients with DMS and 24 with RMS (77±12 vs. 59±14 y, p=0.001) were reviewed. Eligible patients had at least mild MS and a mean gradient of ≥4 mmHg. Patients with LV ejection fraction <50%, heart rate ≥100 beats per minute, greater than mild mitral or aortic regurgitation, severe aortic stenosis, or history of prior mitral balloon valvuloplasty were excluded. MVA was estimated via the continuity equation. Mean transmitral flow rate was calculated by dividing LV outflow tract stroke volume by the diastolic filling period. **Results:** Mean transmitral flow rate was significantly higher in DMS vs. RMS (171±47 vs 141±69 ml/s, p=0.021). There was a weak but significant correlation between mean gradient and mean transmitral flow rate (r=0.38, p=0.01) in DMS. Patients with MVA ≤1.0 cm^2 and MVA >1.5 cm^2 had significantly different flow rates (197±40 vs 137±45 ml/s; p=0.001). Mean transmitral flow rate ≤149 ml/sec predicted MVA ≤1.0 cm^2 with 75% sensitivity and 83% specificity (AUC=0.77, p=0.003), while a rate ≤190 ml/s predicted MVA ≤ 1.5 cm^2 with 83% sensitivity and 59% specificity (AUC=0.72, p=0.007). LV stroke volume ≤35 ml/m^2 was observed in 45% of DMS patients and 42% of RMS patients (p=0.079). In these patients with low LV stroke volume, mean flow rate remained significantly higher among DMS patients than in those with RMS (143±36 vs 109±52 ml/s, p=0.026). **Conclusion:** Mean transmitral flow rate is significantly higher in DMS than RMS. Mean gradients do not correlate strongly with MS severity in DMS. For patients with DMS, the mean transmitral flow rate may be a better surrogate for stenosis severity than the mean gradient.

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Predictors of Exercise Capacity in a Contemporary Group of Patients with at Least Moderate Mitral Stenosis Undergoing Treadmill Stress Echocardiography

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Background: With evolving demographics in the United States, the etiology of mitral stenosis (MS) is changing from predominantly rheumatic to a mix of rheumatic, post-surgical and degenerative. In evaluation of these patients, treadmill stress echocardiography (TSE) aids in symptom evaluation and timing of mitral valve (MV) surgery. In a contemporary group of patients with ≥ moderate MS undergoing TSE, we sought to assess potential factors associated with exercise capacity. **Methods:** We studied

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515 consecutive (asymptomatic/atypical symptoms with normal left ventricular ejection fraction) patients with ≥ moderate MS (mean gradient ≥ 5 mmHg at rest, excluding hypertrophic cardiomyopathy and subaortic membrane) who underwent rest and TSE between 1/2003 and 12/2013. MS was characterized as rheumatic, post-surgical (prior repair/replacement), and degenerative (mitral annular calcification). Clinical, resting, and TSE data were recorded. **Results:** Relevant baseline data are shown in Table 1. Univariable and multivariable logistic regression analysis, demonstrating the association between 100% age-gender predicted metabolic equivalents (AGPMETs) and various potential predictors is shown in Table 2. There was only a modest correlation (r=-0.48, p<0.001) between AGPMETs and right ventricular systolic pressure (RVSP, Figure 1), explaining ~4% of the association. **Conclusion:** In a contemporary group of MS patients undergoing rest and TSE at a US tertiary care center, RVSP, along with body surface area and beta-blocker use were independently associated with exercise capacity, while MS etiology or resting/peak-stress MV gradients were not.

Table 1: Relevant Baseline Characteristics of the Study Sample

Variable	Total population (N=515)	Age-gender predicted METs < 100% (N=305)	Age-gender predicted METs ≥ 100% (N=210)	p-value
Age (years)	60±14	60±12	59±12	0.19
Female gender	295 (57%)	180 (59%)	115 (55%)	0.19
Body surface area (m^2)	1.88±0.23	1.88±0.22	1.87±0.20	0.21
Hypertension	240 (47%)	136 (45%)	104 (50%)	0.16
Atrial Fibrillation	225 (44%)	130 (43%)	95 (45%)	0.56
Obstructive coronary disease	29 (6%)	19 (4%)	10 (2%)	0.31
Beta blockers	323 (63%)	209 (69%)	114 (54%)	<0.001
Mechanism of mitral stenosis				
Rheumatic	170 (33%)	109 (36%)	61 (29%)	0.09
Post surgical	245 (48%)	133 (44%)	112 (53%)	
Degenerative	100 (19%)	63 (21%)	37 (18%)	
Resting and Treadmill Exercise Echocardiography				
Left ventricular ejection fraction (%)	58±5	58±5	58±4	0.44
Resting peak mitral valve gradient (mmHg)	19±6	19±7	19±6	0.48
Resting mean mitral valve gradient (mmHg)	8.5±3	8.7±3	8.4±3	0.15
≥ Moderate mitral regurgitation (Rest)	148 (29%)	93 (30%)	55 (26%)	0.29
≥ Moderate tricuspid regurgitation (Rest)	97 (19%)	56 (18%)	41 (20%)	0.74
Resting RVSP (mmHg)	39±13	39±11	38±11	0.21
Maximum METs	7.1±2	6.2±2	8.5±2	<0.001
% Age-gender predicted METs	95±29	76±17	122±19	<0.001
Total exercise time (seconds)	398±149	340±129	483±134	<0.001
Post stress RVSP (mmHg)	61±14	61±13	61±14	0.89
Post stress peak mitral gradient (mmHg)	32±11	32±11	32±11	0.92
Post stress mean mitral gradient (mmHg)	17±7	17±7	17±7	0.30

Table 2:

Logistic regression analysis demonstrating the association of various potential predictors and < 100% achieved age-gender predicted metabolic equivalents

	Univariable analysis		Multivariable analysis	
Variable	Odds ratio [95% CI]	p-value	Odds ratio [95% CI]	p-value
Age	N/A			
Gender	N/A			
Body surface area	3.51 [1.57-3.81]	0.002	3.79 [1.65-8.69]	0.001
Hypertension	1.21 [0.85-1.75]	0.27		
Obstructive coronary disease	1.33 [0.60-2.96]	0.48		
Atrial fibrillation	1.11 [0.77-1.59]	0.58		
Beta blockers	1.83 [1.27-2.65]	0.001	1.83 [1.25-2.68]	0.001
Etiology of Mitral Stenosis				
Rheumatic (Reference)	N/A			
Prior mitral repair/replacement	1.05 [0.63-1.77]	0.85		
Degenerative	1.43 [0.89-2.32]	0.14		
Resting Echocardiography				
Left atrial area	1.13 [0.84-1.52]	0.41		
Left ventricular ejection fraction	1.01 [0.97-1.06]	0.44		
Mean mitral valve gradient	1.09 [0.90-1.34]	0.32		
Resting RVSP (for every 10 mmHg increase)	1.23 [1.05-1.45]	0.007	1.17 [1.04-1.32]	0.009
Treadmill Stress Echocardiography				
Peak-stress mean mitral valve gradient	1.07 [0.88-1.41]	0.51		
Peak-stress RVSP (for every 10 mmHg increase)*	1.20 [1.04-1.51]	0.01		

*Findings similar if peak-stress RVSP substituted for resting RVSP

Abbreviation: RVSP = Right ventricular systolic pressure

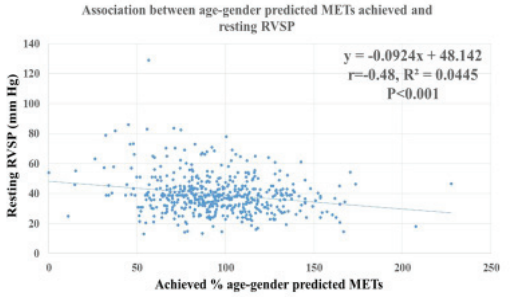

Figure 1: Linear regression analysis demonstrating association between resting RVSP and % age-gender predicted METs achieved

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Gender Related Differences in Left Ventricular Response to Aortic Stenosis

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Background: Recent studies and clinical observations have shown gender-related differences in phenotypic presentations of aortic stenosis (AS). We investigated the gender-specific differences in left ventricular (LV) response to increased afterload as a mechanism of paradoxical low-flow, low-gradient AS in a murine model of severe AS. **Methods:** We studied the 2D and Doppler echocardiographic data of 100 mice (51% female, age 9 months, low-density lipoprotein receptor-deficient apolipoprotein B-100-only fed with high-fat diet) that developed severe AS. LV volumes, LV mass index, ejection fraction, cusp separation distance, and peak aortic velocity were compared between genders. Propensity score matching was performed to compare genders based on heart rate (HR). **Results:** Females had lower body weight (p< 0.001), end-diastolic volume (p=0.002), stroke volume, (p<0.0001), cardiac output (p=0.015), peak aortic valve velocity (p=0.005), and higher HR (p= 0.004). Mean cusp separation distance (p=0.796), EF (p=0.9), ventricular septum. (p=0.56), posterior wall (p=0.37) and LV to body weight ratio (p=0.99) were similar in both groups. Propensity score matching based on HR showed end-diastolic volume, cardiac output and peak velocity to be persistently lower in females despite having the same severity of stenosis. **Conclusions:** Our data showed that hemodynamic alterations in response to chronic severe AS manifest differently between genders. Females develop lower stroke volume, cardiac output and peak aortic valve velocity in the presence of normal EF compared to males despite similar degree of stenosis. These observations suggest a gender related propensity in developing LV response to AS and may be relevant for development of paradoxical low-flow, low-gradient severe AS.

Table 1: Propensity score-matched comparison of HR between genders

	Gender		
	F (n=43)	M (n=37)	p
Body Weight (BW)	22.2 ± 2.7	26.5 ± 4.0	0.000
HR, bpm	650 ± 42	640 ± 44	0.323
IVSD, mm	0.98 ± 0.15	0.99 ± 0.14	0.957
LVID, mm	2.28 ± 0.67	2.42 ± 0.62	0.201
PWD, mm	1.06 ± 0.21	1.09 ± 0.34	0.935
EDV, ml	28.8 ± 7.5	33.0 ± 9.4	0.027
ESV, ml	6.0 ± 3.6	7.0 ± 4.6	0.282
SV, ml	22.8 ± 4.6	26.0 ± 6.1	0.009
CO	14883 ± 3100	16664 ± 3945	0.027
EF, %	80.6 ± 7.0	80.3 ± 8.3	0.842
FS, %	48.3 ± 7.3	48.5 ± 8.8	0.946
LV mass, mg	69.0 ± 12.6	77.0 ± 20.6	0.101
LVM / BW	3.17 ± 0.82	3.04 ± 0.99	0.561
Peak Ao velocity, cm/sec	2146 ± 436	2361 ± 745	0.020
Cusp separation, mm	0.82 ± 0.16	0.87 ± 0.17	0.194

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Relationship Between Improvement of Valvuloarterial Impedance and Left Atrial Volume Reduction After Transcatheter Aortic Valve Replacement: A Comparison Between Valvuloarterial Impedance and Mean Pressure Gradient

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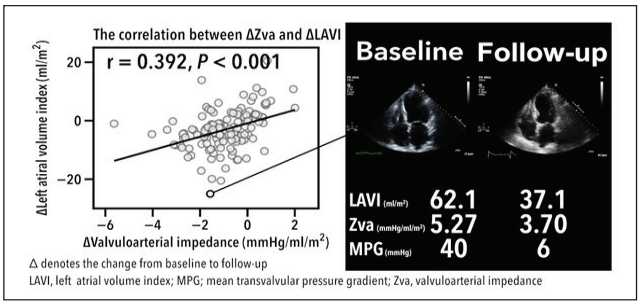
Background: Left ventricular diastolic dysfunction involves elevated left ventricular filling pressure and left atrial enlargement. Left atrial enlargement is associated with symptoms and mortality in aortic stenosis. In aortic stenosis, valvuloarterial impedance (Zva) is an index which represents global load. Zva consists both valvular and vascular load. While, mean pressure gradient (MPG) is a conventional index which represents the only valvular load. The improvement of Zva after transcatheter aortic valve replacement (TAVR) has been reported. We presumed that the improvement of Zva should be related to the left atrial volume reduction coupling with the improvement of diastolic dysfunction after TAVR. The present study aimed to compare the correlation between the change of (Δ; Δ denotes the change from baseline to follow-up) Zva and Δleft atrial volume index (LAVI) and that of ΔMPG and ΔLAVI. **Methods:** We reviewed transthoracic echocardiography at baseline and follow-up (> 90 days after TAVR) in 129 patients without significant aortic regurgitation, or significant mitral regurgitation, or significant mitral stenosis, or atrial fibrillation, or history of myocardial infarction, who underwent TAVR from January 2011 to December 2015. Zva was calculated using following formula: Zva = [(systolic blood pressure + mean transvalvular pressure gradient)] / (stroke volume index). Left atrial volume just before mitral valve opening was measured by the area-length method from two- and four-chamber views and indexed to body surface area as LAVI. Pearson's correlation coefficient was used to see the relation between ΔZva and ΔLAVI. **Results:** There was no significant correlation between ΔMPG and ΔLAVI ($r = 0.165$, $P = 0.062$). However, there was a significant correlation between ΔZva and ΔLAVI ($r = 0.392$, $P < 0.001$) (Figure). **Conclusions:** Left atrial volume reduction was related to the improvement of Zva after TAVR.



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Association of Mitral Regurgitation and Adverse Cardiac Remodeling and Hemodynamics in Patients with Low Flow Low Gradient Severe Aortic Stenosis

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Background: Mitral regurgitation commonly occurs in conjunction with severe aortic stenosis. It remains unclear the impact of co-existing MR on cardiac remodeling in patients with low-flow low-gradient aortic stenosis (LFLGAS). We examined the association of MR on cardiac remodeling features in patients with LFLGAS. **Methods:** We performed a search of our institutional echocardiographic database from 2009-2016 for patients with LFLGAS (stroke volume index (SVi) <35ml/m², aortic valve area (AVA) <1.0cm², mean aortic gradient< 40mmHg, peak aortic gradient<64 mmHg). Patient were grouped by presence of moderate or greater MR (+MR) or mild or less MR (-MR) and further subgroupedsub grouped by LFLGAS with low left ventricular ejection function(LVEF): low EF (<50%) and LFLGAS with normal LVEF: (≥50%). Cardiac remodeling measures were compared (Tables) between the subgroups. **Results:** Overall, +MR patients had greater left ventricular (LV) mass, LV and left atrialrticle (LA) size, right ventricular systolic pressure(RVSP) and lower SVi than -MR pts. Additionally, However, +MR pts had a lower relative wall thickness (RWT) c/w less concentric hypertrophy and hence increased wall stress compared to than -MR patients. In patients with low LVEF and LFLGAS, +MR was associated with worse cardiac remodeling (greater LV mass, LV size , lower RWT) and worse hemodynamics (greater RVSP and lower SVi) than in patients with normal LVEF and LFLGAS. **Conclusion:** Co-existing moderate or greater MR in patients with LFLGAS is associated with adverse cardiac remodeling with increased LV and LA size, and lower RWT (a marker of increased wall stress) and worse cardiac hemodynamics with decreased SVi and increased RPVSP. This adverse effect on remodeling and hemodynamics may guide clinical decision making in patients with LFLGAS.

baseline characteristics and left ventricular geometry and hemodynamics									
		LFLGAS				LFLGAS			
		Total			low LVEF			normal LVEF	
	+MR (n=357)	-MR (n=642)	P value	+MR (n=191)	-MR (n=181)	P value	+MR (n=166)	-MR (n=461)	P value
Age	82±10	78±12	<0.05	81±9	80±10	=0.42	83±10	78±12	<0.05
Gender	209(58%)	411(64%)	0.10	134(70%)	141(78%)	=0.09	75(45%)	268(58%)	<0.05
AVA	0.74±0.13	0.79±0.12	<0.05	0.73±0.14	0.75±0.14	=0.05	0.75±0.12	0.80±0.11	<0.05
Mean gradient	26.4±1.90	27.9±7.17	<0.05	25.3±8.44	23.8±8.43	=0.05	27.7±7.1	28.9±6.4	=0.06
Peak gradient	47.2±13.8	50.0±12.6	<0.05	45.1±14.4	45.9±14.1	=0.58	49.6±12.8	51.7±11.6	=0.05
SVi	25± 6	27± 5	<0.05	23± 6	25 ± 5	<0.05	27 ± 5	28 ± 5	<0.05
LVEDV	116±44	93±37	<0.05	140±39	122±43	<0.05	88±32	81±27	<0.05
LVESV	67±41	45±32	<0.05	95±35	80±36	<0.05	35±16	31±14	<0.05
RWT	0.47±0.14	0.53±0.14	<0.05	0.40±0.10	0.46±0.14	<0.05	0.56±0.13	0.56±0.13	=0.69
LVmass/ BSA	119±31	103±29	<0.05	126±29	120±31	=0.06	112±32	96±26	<0.05
LAD	45±7	41±7	<0.05	45±6	44±7	=0.32	45±7	39±7	<0.05
RVSP	54±16	47±16	<0.05	54±14	50±15	<0.05	54±17	45±16	<0.05

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Relief of Aortic Stenosis is Not Associated with Reverse Ventricular Remodeling in the Elderly

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Background: Surgical relief of aortic stenosis has been associated with reverse left ventricular (LV) remodeling in middle aged adults. Whether elderly adults undergoing transcatheter aortic valve replacement (TAVR) exhibit similar degrees of reverse remodeling is less well known. **Methods:** One hundred sixty-one patients with complete echocardiograms before and one year after TAVR were studied. LV mass, relative wall thickness and LV geometry, and LV volumes and ejection fraction were calculated as described in the ASE Guidelines. Aortic valve Doppler gradients prior to and one year after TAVR were compared for each patient. Paired sample t-tests compared pre- and post-TAVR values. Linear regression was used to explore the effects of baseline echocardiographic characteristics on reverse remodeling during follow up. Alpha was set at 0.05 for all analyses. **Results:** Complete pre- and post-TAVR echocardiograms were available in 151 patients (mean age 80.8 ± 8.3 years, 51% male, and 61% with reduced LVEF). Mean Doppler gradient across the aortic valve was reduced from 46.7 ± 12.5 mm Hg to 11.5 ± 6.4 mm Hg (p<0.01). LV mass index decreased from 113.0 ± 33.0 g/m2 to 96.6 ± 31.5 g/m2 (p<0.01) at one year, with 106 (66.3%) patients having elevated LV mass index pre-TAVR compared with 74 (46.3%) one year later (p=0.31). Components of LV mass are presented in the Table. Change in indexed LV mass was not statistically significantly associated with change in aortic gradient (p=0.15). In the final multivariable model, female sex (p=0.04) and greater baseline LV mass index (p<0.01) but not age, change in gradient, or baseline ejection fraction (multivariable p-values 0.60, 0.18, and 0.17, respectively) were associated with regression of indexed LV mass. **Conclusions:** Regression, but not normalization, of indexed LV mass is typical after TAVR for severe aortic stenosis in elderly patients. Reduction of the transvalvular gradient is not associated with degree of regression of LV mass, suggesting other hemodynamic or structural factors determine LV remodeling in this population.

Table. Left Ventricular Geometry, Pre- and 1-year-post- Transcatheter Aortic Valve Replacement for Severe Aortic Stenosis

	Pre-TAVR	1-year Post-TAVR	P-value
Interventricular septal thickness, diastole (mm)	12.8 ± 2.8	11.8 ± 2.6	<0.01
Left ventricular internal diameter, diastole (mm)	46.2 ± 8.0	44.7 ± 8.5	0.13
Posterior wall thickness, diastole (mm)	11.8 ± 2.5	10.6 ± 2.3	<0.01
Relative wall thickness	0.55 ± 0.16	0.53 ± 0.17	0.15
Left ventricular mass, indexed to body surface area (g/ m2)	113.0 ± 33.0	96.6 ± 31.5	<0.01

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The Obesity Paradox: Improved Survival in Obese Compared to Non-Obese Patients with Medically-Managed Severe Aortic Stenosis and Preserved Left Ventricular Ejection Fraction

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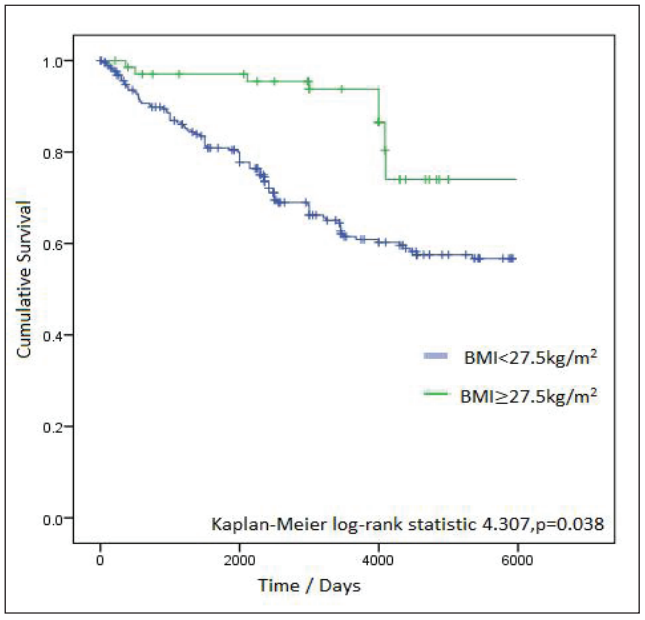
Background: The obesity paradox has been described haemodialysis and heart failure, where obesity was linked to improved survival. We explored this phenomenon in medically-managed severe aortic stenosis (AS). **Methods:** We divided 347 patients with medically-managed severe AS (aortic valve area<1cm²) into obese (body mass index, BMI, Asian cut-off>27.5kg/m²) and non-obese (BMI≤27.5kg/m²) groups, comparing clinical and echocardiographic profiles. Kaplan-Meier curves were constructed to compare

mortality. **Results:** 20.5% (n=71) patients were obese (BMI 30.5±3.2vs22.6±3.0kg/m^2). There were more male (73.2%vs55.4%,p=0.007) obese patients, with higher incidence of hypertension (76.6%vs60.9%,p=0.021), hyperlipidaemia (57.8%vs42.7%,p=0.033) and diabetes (54.7%vs35.5%p=0.006). Left ventricular (LV) mass index (121.6±38.2vs111.4±32.9g/m^2) and left atrial diameter (42.7±7.6vs38.7±9.9mm) were larger in obese patients, while LV outflow tract diameter (19.2±1.7vs19.9±2.0mm) and stroke volume index (35.1±0.1vs42.0±11.4ml/m^2) were smaller. There were no significant differences in aortic valve disease severity, but obese patients demonstrated improved survival (37.7%vs41.4% Kaplan-Meier log-rank 4.307,p=0.038) over a mean follow-up 9.6±5.6 years. **Conclusions:** We demonstrated improved survival in obese patients with medically-managed severe AS despite increased incidence of cardiovascular risk factors.

Table 1: Univariate analysis comparing obese (BMI≥27.5g/m^2) to non-obese (BMI<27.5kg/m^2) patients in severe AS with preserved LVEF>50%

	Obese (n=71)	Non-obese (n=276)	Odds Ratio/Mean Difference (95% CI)	P-value
Age (years)	68.4 (±11.8)	72.36 (±13.0)	-4.0 (-7.4 - -0.7)	0.019
Body mass index (g/m^2)	30.5 (±3.2)	22.6 (±3.0)	7.9 (7.1 – 8.7)	<0.001
Gender (Male)	73.2%	55.4%	2.20 (1.24 – 3.92)	0.007
Hypertension	76.6%	60.9%	2.10 (1.11 – 3.97)	0.021
Hyperlipidaemia	57.8%	42.7%	1.84 (1.046 – 3.23)	0.033
Diabetes mellitus	54.7%	35.5%	2.20 (1.25 – 3.83)	0.006
Ischaemic heart disease	25.0%	31.8%	0.71 (0.38 – 1.35)	0.296
Chronic kidney disease	15.6%	13.6%	1.17 (0.54 – 2.55)	0.687
Left ventricular ejection fraction (%)	66.3 (±8.1)	66.1 (±7.1)	0.1 (-1.8 – 2.1)	0.884
Left ventricular mass index (g/m^2)	121.6 (±38.2)	111.4 (±32.9)	-10.2 (-20.0 – -0.3)	0.043
Left ventricular internal diameter in diastole (mm)	46.0 (±5.8)	45.6 (±6.4)	0.4 (-1.2 – 2.1)	0.621
Left ventricular interventricular septal diameter in diastole (mm)	11.7 (±2.3)	11.7 (±2.6)	0.0 (-0.6 – 0.7)	0.943
Left ventricular posterior wall diameter in diastole (mm)	11.3 (±1.7)	10.9 (±1.9)	0.4 (-0.1 – 0.9)	0.115
Left atrial diameter (mm)	42.7 (±7.6)	38.7 (±9.9)	4.0 (1.5 – 6.5)	0.002
LVOT diameter (mm)	19.2 (±1.7)	19.9 (±2.0)	-0.6 (-1.2 – -0.1)	0.013
Stroke volume index	35.1 (±0.1)	42.0 (±11.4)	7.0 (-9.9 - -4.1)	<0.001
Low-flow (SVI<35ml/m^2)	43.7%	32.2%	1.63 (0.96 – 2.77)	0.071
End-systolic wall stress	62.9 (±19.1)	62.3 (±18.3)	0.6 (-4.3 – 5.4)	0.813
Aortic valve area (cm^2)	0.79 (±0.18)	0.78 (±0.17)	-0.01 (-0.03 – 0.06)	0.559
Transaortic peak velocity (cm/s)	367.8 (±98.8)	379.8 (±94.8)	-12.1 (-37.1 – 13.0)	0.344
Transaortic mean pressure gradient (mmHg)	34.0 (±21.8)	36.2 (±19.7)	-2.1 (-7.4 – 3.1)	0.426
Mortality	37.7%	41.4%	0.86 (0.50 – 1.48)	0.576

Figure 1: Comparing mortality in obese to non-obese patients in medically managed severe AS with preserved LVEF>50%



P1-134

Strain Echocardiography Derived Mechanical Dispersion Identifies Mitral Valve Prolapse Patients at Higher Arrhythmic Risk

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Background: Mitral valve prolapse (MVP) is a common valvulopathy affecting 2-3% of the general population. A subset of MVP patients are at increased risk of ventricular arrhythmias and/or sudden cardiac death, particularly those with bileaflet involvement and myocardial fibrosis on cardiac magnetic resonance imaging. Abnormal speckle-tracking echocardiography (STE), particularly mechanical dispersion, has been shown to be predictive of arrhythmic risk in other conditions with underlying myocardial fibrosis including ischemic heart disease and dilated cardiomyopathy. The aim of this study was to evaluate whether STE may further help in arrhythmic risk stratification of patients with MVP. **Methods:** We reviewed the UCSF clinical and echo database and identified 32 consecutive arrhythmic MVP (A-MVP) patients from 2013-2016 with a history of complex ventricular arrhythmia on Holter/event monitor (n=9 with high PVC burden or bigeminy/trigeminy, n=16 with ventricular tachycardia), or implantable cardioverter-defibrillator placement (n=7) along with 27 consecutive MVP patients without arrhythmic complications (NA-MVP). Additionally, we obtained clinical and echocardiographic data from 25 age/gender matched controls free of significant cardiac disease. STE was performed using the TomTec Image Arena Version 4.6 Software to calculate global longitudinal strain (GLS) as the average peak longitudinal strain from a 18-segment left ventricular (LV) model and mechanical dispersion as the standard deviation of the time to peak strain of each LV segment. **Results:** MVP patients had significantly higher MD when compared to controls (52 vs 41, p = 0.01) despite similar LV ejection fraction (62.2% vs 62%, p = 0.7) and similar GLS (-19.7 vs -20.5, p = 0.34). Within the MVP group, A-MVP and NA-MVP patients were similar with regards to age, gender, hypertension, diabetes, LV ejection fraction, and GLS (all p>0.05). None had coronary artery disease. The number of individuals with bileaflet MVP and the degree of mitral regurgitation (mostly trace or mild in both groups) were similar in A-MVP and NA-MVP (p > 0.05). However, patients with A-MVP exhibited a higher degree of mechanical dispersion when compared to NA-MVP (59 ms vs 45 ms, p< 0.001) suggesting increased heterogeneity of ventricular contraction/electrical dispersion in A-MVP. **Conclusion:** STE-derived mechanical dispersion may help identify MVP patients at higher arrhythmic risk. Further studies are warranted to correlate this echocardiographic parameter with myocardial fibrosis in MVP.

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A Multi-Biomarker Approach Provides More Comprehensive Pathophysiologic Profiling of Valvular Aortic Stenosis

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Background: Circulating biomarkers may help identify advanced disease and risk stratify patients with aortic stenosis (AS). Information on more novel biomarkers is sparse and comparative data lacking. We aimed to correlate echocardiographic indexes of AS and functional capacity with levels of N-terminal pro-B-type natriuretic peptide (NT-proBNP), high-sensitivity troponin T (hs-TnT), growth differentiation factor 15 (GDF15) and soluble ST2. **Methods:** We analyzed 172 pts (age 69±11 years, 56% female) with moderate to severe AS enrolled in a prospective multicenter study. Exclusions included >mild aortic regurgitation or organic mitral valve disease, LV ejection fraction <50%, NYHA class >II, recent heart failure hospitalization or myocardial infarction, cardiac surgery and serum creatinine >200 μmol/L. Functional capacity was assessed by 6-minute walk distance. **Results:** Of 172 pts, 47 (27%) had bicuspid valve. Symptoms were mild dyspnea in 24 pts (14%), chest pain in 18 (11%) and syncope in 2 (1%). Coronary artery disease was preexistent in 24 pts (14%). Peak aortic velocity was 3.8±0.7 m/s, mean aortic gradient 36±15 mmHg, continuity equation aortic valve area (AVA) 0.91±0.26 cm^2 and LV ejection fraction 65±5%. Severe AS (BSA-indexed AVA <0.6 cm^2/m^2) was present in 119 pts (69%). Table 1 displays correlations between echocardiographic data and log-transformed biomarker levels. Table 2 shows results of multiple linear regression analyses of biomarker associations with representative echocardiographic parameters and functional capacity. **Conclusions:** The biomarker(s) which best correlate with or predict key measures in pts with AS are (a) for hemodynamic severity: NT-proBNP, (b) LV systolic function: hs-TnT and secondarily NT-proBNP, (c) LV diastolic function: NT-proBNP and hs-TnT equally, and (d) 6-minute walk distance: GDF15.

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Table 1.

	NT-proBNP		hs-TnT		GDF15		ST2	
	r	*P value*	*r*	*P value*	*r*	*P value*	*r*	*P value*
Peak aortic velocity	0.32	<0.001	0.09	0.23	-0.10	0.20	0.006	0.94
Mean aortic gradient	0.29	<0.001	0.07	0.39	-0.10	0.18	0.02	0.80
AVA	-0.31	<0.001	-0.16	0.03	-0.09	0.27	-0.003	0.96
AVA index*	-0.22	0.004	-0.16	0.03	-0.03	0.67	-0.05	0.49
Energy loss index*	-0.17	0.03	-0.13	0.08	0.03	0.69	-0.03	0.66
LV ejection fraction	-0.06	0.43	-0.20	0.009	-0.11	0.16	-0.08	0.32
Annular systolic velocity†	-0.32	<0.001	-0.36	<0.001	-0.11	0.16	0.05	0.50
LV global longitudinal strain	0.20	0.008	0.38	<0.001	0.18	0.02	0.02	0.84
LV mass index*	0.29	<0.001	0.35	<0.001	0.01	0.88	0.02	0.81
Left atrial volume index*	0.49	<0.001	0.24	0.001	0.06	0.42	0.05	0.53
Annular e' velocity†	-0.33	<0.001	-0.39	<0.001	-0.21	0.007	0.02	0.76
E/e' ratio†	0.43	<0.001	0.43	<0.001	0.19	0.01	0.01	0.90
Tricuspid regurgitation peak velocity	0.42	<0.001	0.23	0.004	0.17	0.03	-0.04	0.62
6-minute walk distance	-0.16	0.06	-0.23	0.009	-0.36	<0.001	-0.11	0.19

*Indexed to BSA; †Average of septal and lateral annular velocities

Table 2.

	AVA		LV global longitudinal strain		Annular systolic velocity		E/e' ratio		6-minute walk distance	
	Co-efficient	*P value*	*Co-efficient*	*P value*	*Co-efficient*	*P value*	*Co-efficient*	*P*	*Co-efficient*	*P value*
NT-proBNP	-0.07	<0.001	-	-	-0.19	0.02	1.37	<0.001	-	-
hs-TnT	-	-	1.61	<0.001	-0.47	0.001	2.46	<0.001	-	-
GDF15	-	-	-	-	-	-	-	-	-53.94	<0.001
ST2	-	-	-	-	-	-	-	-	-	-

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Left Atrial Deformation in Patients with Moderate to Severe Aortic Stenosis and Heart Failure

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Background: The presence of heart failure (HF) in patients with moderate to severe aortic stenosis (AS) is thought to be related to the presence of diastolic dysfunction. Assessment of left atrial (LA) deformation, a novel and reproducible technique, may be more closely associated with HF in patients with AS than traditional parameters, such as e' velocities and E/e' ratio, influenced by left ventricular (LV) hypertrophy and mitral annular calcification. The aim of this study was to compare the association of both methods with the presence of HF in patients with AS. **Methods:** 71 patients with moderate and severe AS (< 1.5cm^2) and preserved LV ejection fraction were included. The presence of HF was defined as NYHA≥2 and NT-proBNP≥360pg/mL. LA deformation was evaluated using 2D echocardiography speckle tracking analysis. Functional capacity was assessed using 6-minute walk test distance and 5 meters gait speed. **Results:** Patients with HF were significantly older with higher NT-proBNP level (Table 1). AS severity or LV geometry and function were not predictive of HF. Parameters of LV diastolic function, e' velocities or E/e' ratio, did not show significant differences between groups. LA negative late diastolic strain, positive systolic and negative early and late diastolic strain rates (contractile, reservoir and conduit function) were significantly worse in symptomatic patient. Patients with HF walked a significantly shorter 6-minute walk distance compared to asymptomatic (Δ 64m, p=0.020) with a significantly slower 5 meters gait speed. Statistically significant correlations were found between LA positive systolic strain and NT-proBNP (r=-0.388, p=0.002), 6-minute walk test distance (r=0.420, p=0.001) and 5 meters gait speed (r=0.420, p=0.001). All other LA strain parameters showed significant correlations with those parameters. **Conclusion:** Evaluation of LA deformation using novel tools such as speckle tracking analysis may be more closely related to the presence of HF compared to traditional evaluation of diastolic function in patients with moderate to severe AS.

Table 1. Echocardiographic parameters according to symptomatic status in patients with moderate to severe aortic stenosis

Variables	Asymptomatic n=58 (82%)	HF n=13 (18%)	p*
Age, years	67.0 ± 12.7	78.0 ± 6.2	0.001
NT-proBNP, ng/L	218.5 ± 268.5	954.2 ± 832.9	<0.001
Echocardiographic parameters			
AS severity			
Peak aortic velocity, m/s	4.16 ± 0.80	4.17 ± 0.66	0.666
Mean aortic gradient, mmHg	45.5 ± 18.0	46.4 ± 14.3	0.618
Valve area, cm^2	0.98 ± 0.23	0.86 ± 0.27	0.108
Valvulo-arterial impedance	3.57 ± 0.88	3.98 ± 0.94	0.248
LV geometry and function			
Mass, g/m^2	93.6 ± 20.0	94.6 ± 28.1	0.917
Stroke volume, mL/m^2	48.1 ± 7.4	47.4 ± 9.9	0.778
Ejection fraction, %	64.7 ± 3.9	62.6 ± 6.0	0.461
Global longitudinal strain, %	-19.0 ± 2.6	-18.4 ± 2.7	0.634
e', m/s	0.06 ± 0.02	0.06 ± 0.01	0.975
E/e' ratio	14.3 ± 6.6	17.3 ± 6.1	0.053
LA geometry and function			
Indexed left atrial volume, mL/m^2	34.5 ± 8.6	43.1 ± 7.9	0.002
Positive systolic strain, %	9.4 ± 4.1	6.9 ± 3.3	0.070
Negative late diastolic strain, %	-14.0 ± 3.6	-11.3 ± 3.3	0.039
Positive systolic strain rate, s^{-1}	1.22 ± 0.34	0.96 ± 0.21	0.032
Negative early diastolic strain rate, s^{-1}	-0.84 ± 0.35	-0.44 ± 0.53	0.022
Negative late diastolic strain rate, s^{-1}	-1.68 ± 0.57	-0.96 ± 0.91	0.008
Functional capacity			
6MWTD, m	430.5 ± 114.8	366.5 ± 80.1	0.020
5-meter gait speed, m/s	1.95 ± 0.75	1.45 ± 0.59	0.007

* Wilcoxon-Mann-Whitney test with a significant p-value determined as < 0,05.
AS: aortic stenosis; HF: heart failure; LA: left atrium; LV: left ventricle; 6MWTD: 6-minute walk test distance.

P1-137

Increased Risk of Myocardial Infarction and Cardiac Death after Renal Transplant in Patients with Pre-Transplant Echocardiographic Evidence of Mitral Annular Calcification

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Background: Mitral annular calcification (MAC) is a common echocardiographic finding among patients with chronic kidney disease. An increased risk of major adverse cardiac events (MACE) in patients with MAC has been shown. The risk of MACE after renal transplant (RT) in patients with MAC identified on a pre-transplant echocardiogram has not been studied. We aimed to determine the prognostic value of MAC in RT recipients. **Methods:** In a retrospective cohort of consecutive RT recipients, pre-transplant MAC presence and severity on transthoracic echocardiography performed within 1 year prior to transplant was determined by an observer blinded to other clinical and imaging data. MAC severity was quantified based on the circumferential MAC extension relative to the mitral valve annulus in parasternal short axis view: mild, <1/3; moderate, 1/3 - 1/2; severe, >1/2. Clinical risk was assessed using the sum of risk factors (range 0 - 8) set-forth by the AHA/ACCF consensus statement on the assessment of RT candidates (age > 60 y, hypertension, diabetes, dyslipidemia, smoking, history of cardiovascular disease, dialysis > 1 y, left ventricular hypertrophy). Subjects underwent pre-transplant stress myocardial perfusion imaging and followed for post-transplant MACE (cardiac death or myocardial infarction). Kaplan-Meier plots, log-rank test and Cox-regression models were used in outcome analysis. **Results:** We analyzed 337 patients (60.5% male; mean age 52.4 ± 12 y; mean dialysis duration 4.2 ± 3.2 y). MAC was present in 80 (23%) patients (mild, 64%; moderate, 33%; severe, 3%). During a mean follow up of 3.1 ± 1.9 y, a total of 74 MACEs were observed. Patients with MAC had higher MACE rate compared to those without MAC (36.2% vs 17.5%, P < 0.001. Fig. 1) with a stepwise increase in MACE risk with increasing MAC severity (Fig 2). The difference in MACE risk remained significant after adjusting for sex, duration of dialysis, sum of AHA/ACCF risk factors, ejection fraction, and burden of global and ischemic perfusion abnormality on myocardial perfusion imaging. **Conclusion:** MAC is an independent predictor of MACE risk in RT recipients with a direct correlation between MAC severity and MACE rates.

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Left Ventricular Global Longitudinal Strain is the Main Determinant of Left Atrial Reservoir Function Improvement After Transarterial Valve Replacement for Isolated Severe Aortic Stenosis

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Background: Left atrial (LA) size and function are altered in severe aortic stenosis (AS). The magnitude of LA reverse remodeling, the changes in LA myocardial deformation and

their predictors after transarterial valve replacement (TAVR) are less known. **Methods:** Of 440 patients who underwent TAVR at our Institution between 1/1-12/31 2017, 65 (age 82 ±8 years, 53% female, AVAi 0.47 ± 0.04 cm2/m2, EF 60.4 ± 9.7%, in NSR) with no more than mild mitral valve disease, underwent 2-D speckle tracking echocardiography (STE) pre and post TAVR (31 had implanted Edwards-Sapien valves) for the evaluation of LV, RV and LA peak global longitudinal strain (LAGS) measured at QRS onset, LA stiffness (LASt) (calculated as E/e'/LAGS), and mechanical dispersion (MD) (standard deviation of time to peak negative strain). The mean time between TAVR and echocardiographic exam was 41± 55 days (median 29 days). The studies were performed on a Phillips IE 33 scanner using frame rates 60-80 Hz and analyzed by one observer on a Q lab software. Unadjusted and adjusted paired-t-test for demographics (model 1) and in addition, for EF, AV peak gradient and AVA (model 2) was done using a mixed model ANOVA. Pearson correlations and multiple regression for the prediction of pre/post TAVR changes of LAGS, LASt and LAMD were performed as well. **Results:** The changes in echo Doppler and STE variables are illustrated below. In fully adjusted models (model 2), the significant associations pre/post TAVR of the Δ LAGS and Δ LASt were with Δ LVGS (r=0.72, p<0.0001 and r = -0.65, p <0.0001, respectively), Δ LASt correlating with Δ RVGS (r = -0.42, p = 0.05). PreTAVR LVGS predicted the improvement in LAGS (r^2 = 0.44, p<0.0001), and preTAVR LVMD predicted Δ LA MD (r^2 =0.16 , p= 0.01). **Conclusions:** 1. Within one year after TAVR for severe AS, there is a significant improvement in LV systolic function, LA reservoir function and decrease in LA stiffness with no significant change in LA mechanical dispersion. 2. Pre TAVR LVGS is the main predictor of improvement in LA mechanical properties 3. These findings highlight the interdependence between the cardiac chambers and may contribute to a better understanding of symptomatic improvement after TAVR.

Variables	Pre TAVR N = 65	Post TAVR N = 65	P-value	
	Mean (SD)		Paired t-test	Repeated measures ANOVA*
AO mean gradient (mmHg)	45.74(17.7)	10.67(5.2)	<0.0001	<0.0001
LA volume index (ml/m^2)	46.94(19.7)	41.70(10.9)	0.09	0.32
LAGS (%)	16.64(12.5)	20.24(10.5)	0.02	0.02
LASt	3.07(4.1)	1.33(1.3)	0.004	0.004
LAMD (ms)	45.54(40.1)	54.08(39.0)	0.24	0.23
EF (%)	61.08(8.5)	62.96(6.9)	0.05	0.08
LVGS (%)	14.73(8.5)	20.14(5.5)	<.0001	<.0001
RVMD (ms)	42.80(44.8)	15.58(17.4)	0.002	0.002
LVMD (ms)	16.33(15.6)	14.81(11.8)	0.54	0.56
RVSP (mmHg)	44.22(13.0)	42.78(9.4)	0.67	0.67
E/e' average	18.43(9.1)	16.94(7.5)	0.13	0.13
E wave deceleration time (msec)	268.0(94.9)	239.4(68.3)	0.05	0.04
* Controlling for age, sex and BSA.				

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Global and Regional Left Ventricular Peak Longitudinal Strain in Bileaflet Myxomatous Mitral Valve Prolapse: In Search of High Risk Markers

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Background: Predictors of arrhythmic sudden cardiac death are challenging to identify in patients with mitral valve prolapse. Increased mechanical traction by prolapsing leaflets has been associated with increased risk of ventricular arrhythmias in patients with Mitral valve prolapse. We hypothesized that areas of increased mechanical traction would have increased regional strain as assessed by speckle tracking echocardiography. **Methods:** We identified patients with myxomatous bileaflet mitral valve prolapse that had not undergone surgery. Patients were divided into 2 groups based on their lateral annular systolic tissue Doppler velocities: ≥ 16 cm/s (Group1) and < 16 cm/s (Group 2). In all patients using speckle tracking echocardiography derived longitudinal strain curves, global and regional LV peak longitudinal strain (PLS), end systolic strain (ESS), peak strain over the whole cycle (PS), post systolic index (PSI) and pre stretch index (PST) were analyzed. Extent of prolapse, mitral annular disjunction, leaflet thickness, LVEF, severity of regurgitation, late gadolinium enhancement on cardiac magnetic resonance and incidence of ventricular arrhythmias were also analyzed. **Results:** A total of 27 patients were identified: 16 patients in Group 1 (mean age 42 ± 3 years; 50 % female) and 11 patients in Group 2 (mean age 54 ± 5 years; 73 % female). Global PLS, ESS and PS in Group 1 was significantly higher than in Group 2 (PLS = -19.8 ± 0.4 % vs. -17.8 ± 0.4 %; P = 0.0005; ESS = -19.6 ± 0.4 % vs. -17.7 ± 0.4 %; P = 0.0007; PS = -20.6 ± 0.4 % vs. -18.4 ± 0.4 %; P < 0.0001). Similarly mid, apical and lateral segments PLS, ESS and PS of Group 1 was higher than in Group 2 (P< 0.05). Four of the group 1 and 3 of the group 2 (p =ns) had ventricular arrhythmias. There were no differences between the two groups in the global or regional PST or PSI, degree of prolapse, leaflet thickness, mitral annular disjunction, LVEF, severity of regurgitation and late gadolinium enhancement. Using bull's-eye mapping it was possible to accurately predict the location for tissue Doppler sample volume in order to obtain the highest Doppler velocity corresponding to the region of the myocardium with the highest mechanical traction by the prolapsing leaflet. **Conclusion:** Global and regional PLS, ESS and PS is higher in patients with mitral valve prolapse with lateral annular systolic tissue velocity ≥ 16 cm/s compared to those with velocity < 16 cm/s. Identification of regions with highest mechanical traction is feasible using speckle tracking and the bull's-eye display of longitudinal strain, thus identifying potential arrythmogenic foci in the myocardium.

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Right Ventricular Free Wall Longitudinal Strain is a Predictor of 1-Year All-Cause Mortality in Elderly Population Undergoing Transcatheter Aortic Valve Replacement

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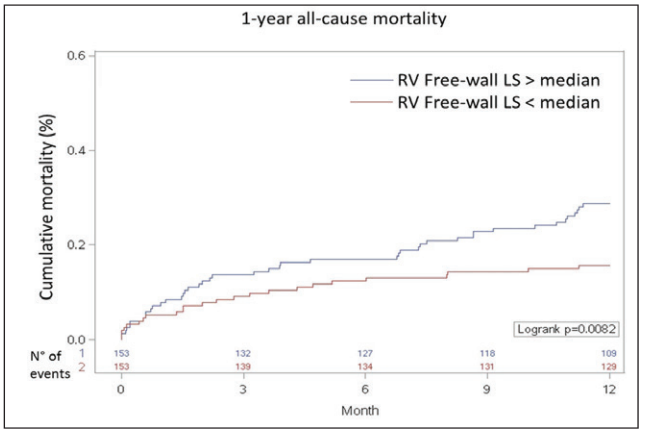
Background: Right ventricular (RV) conventional echocardiographic parameters of systolic function (SF) failed to predict outcomes in patients undergoing transcatheter aortic valve replacement (TAVR). RV free wall longitudinal strain (FW LS) is a novel, sensitive parameter to evaluate SF, and may overcome the limitations of fractional area change (FAC), tricuspid annular plane systolic excursion (TAPSE) and myocardial velocity (S'). RV FW LS application in this population is unknown. We aimed to assess RV FW LS as a predictor of 1 year all cause mortality in a TAVR population. **Methods:** We retrospectively analyzed consecutive patients who underwent TAVR between years 2007-2014 and had available 1-3 months pre-procedural echo in sinus rhythm. Patients with a pacemaker were excluded. Conventional RV SF indices (TAPSE, S', FAC) were measured (Philips) and FW-LS was derived from speckle tracking analyses (TOMTEC). The standard reference was determined as normal or impaired RV SF according to the presence ≥ 50% of: TAPSE<1.7cm, S'<9.5cm/s, FAC<35%. Cox regression analysis for RV FW LS was used to predict 1 year all cause mortality and its median to create subgroups for Kaplan Meier (KM) curves. **Results:** From a total of 613 patients, 354 were included for FW LS analysis (feasibility 57% resulting from 14% of patients excluded due to atrial fibrillation, 12% with pacemaker, 8% with bad quality images, and 9% who had no available echo for analysis). Baseline measurements were as follows for impaired/normal subgroups: TAPSE 1.3±0.3/2.18±0.4 cm, S' 8.2±1.5/11.9±2.3 cm/sec, FAC 35±11/50±9%, and FW LS -21.3±6.4/-25.7±6.0%. By conventional parameters at baseline, 80% of patients had normal RV SF while 20% impaired. Cox regression analysis showed that RV FW LS was a predictor of all cause mortality at 1 year (HR 1.07, 95% CI 1.01-1.12, p<0.01). KM curves showed that patients with worse RV FW LS (above median of -24.7, i.e. less negative values) have higher all cause mortality at 1 year. **Conclusions:** In a real world TAVR population, RV FW LS is a feasible single echo parameter which may assess RV SF by itself. Each single unit of RV FW LS was associated with a 7% risk of increased all cause mortality at 1year follow up. Interestingly, in the impaired RV SF subgroup mean baseline RV FW-LS was more negative than -20%, a cutoff accepted for normal value



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Early Detection of Possible Leaflet Thrombosis After Aortic Valve Neo-Cuspidization Surgery Using Autologous Pericardium

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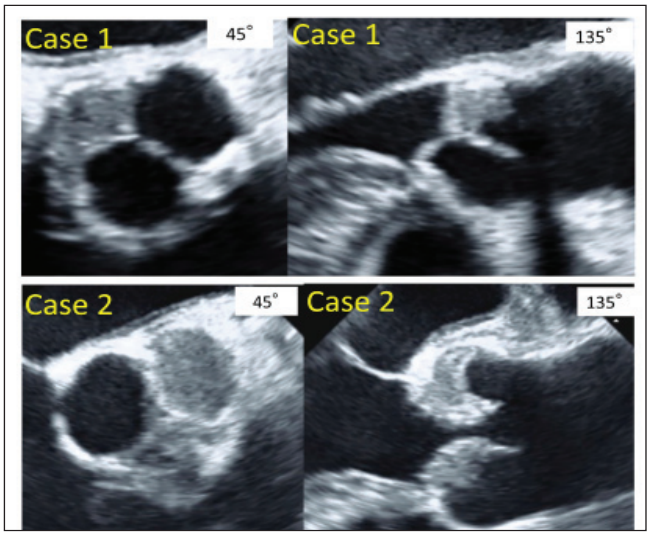
Background: Recent data from multidetector computed tomography imaging studies suggest the leaflet thrombosis after transcatheter aortic valve replacement (TAVR). Usefulness of aortic valve Neo-cuspidization (AVNeo) using autologous pericardium was reported. We assessed the incidence and clinical implications of early leaflet thrombosis using transesophageal echocardiography (TEE) after AVNeo. **Methods:** Of 264 patients who had undergone AVNeo, we studied 200 consecutive patients who underwent TEE within 2 weeks after AVNeo. We assessed the incidence of leaflet thrombosis location and leaflet thickening by three-dimensional TEE. Clinical outcomes including thromboembolic event and mortality were analyzed. **Results:** Leaflet thrombosis was identified in 25 of 200 patients (12.5%) with 32 valve leaflets. Single leaflet thrombosis was observed in 16 of 25 patients. Double leaflet thrombosis were observed in 8 of 25 patients. Thirteen out of 32 leaflet thrombosis located in non-coronary cusps, 9 in left-coronary cusps and 13 in right-coronary cusps. There was no thromboembolic event in 25 patients with leaflet thrombosis. No significant difference was observed in the clinical outcome including thromboembolic event or mortality between patients with and without leaflet thrombosis. **Conclusion:** Early leaflet thrombosis also observed in patients after AVNeo surgery same as TAVR. Incidence of leaflet thrombosis was 12.5% in this study. Incidence of leaflet thrombosis detected by TEE may not be the same compared with previous report by multidetector computed tomography.



P1-142

Significance and Safety of 6-Minute Walk Stress Echocardiography for Patients with Aortic Stenosis

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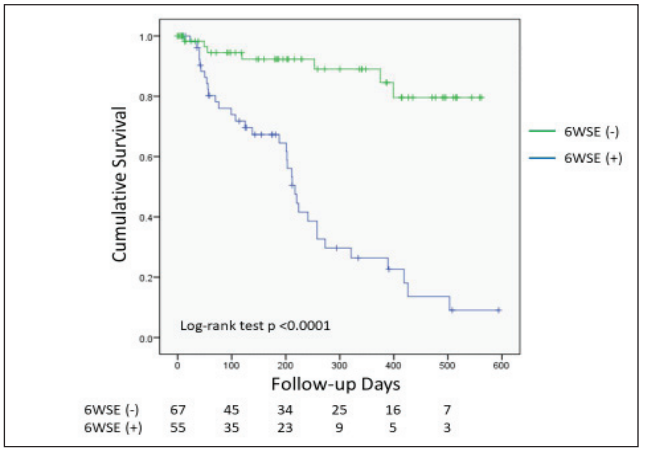
Background: There is a paucity of an investigation of 6-minite walk stress echocardiography (6WSE) for patients with aortic stenosis (AS). The aim of this study is to investigate the significance and safety of 6WSE for AS patients. **Methods:** We prospectively evaluated consecutive 122 ambulatory patients with moderate or severe AS with NYHA I or II from 6/2016 to 12/2017. Positive test by 6WSE was defined by a combination of significant increase of trans-valvular mean pressure (≥20 mmHg) and exercise-induced pulmonary hypertension. The primary clinical endpoints were death, hospitalization due to heart failure and intervention for AS. **Results:** 6WSE was performed safely in all patients without complications although 7 patients were aborted within 6 minutes (2 patients due to short of breath, 2 patients due to chest pain and 3 patients due to fatigue). Positive test by 6WSE was diagnosed in 55 patients (45%). During the follow-up periods, there were 41 patients (34%) with primary endpoints (1 death, 2 hospitalizations due to heart failure and 38 interventions for AS). The survival curves are shown in the Figure. **Conclusions:** 6WSE was successfully performed for all moderate or severe AS patients with NYHA I or II. Additionally, 6WSE was easy, safe and useful for prediction of clinical events for those patients.



P1-143

Association of Tricuspid Regurgitation with Long-Term Outcomes in Patients with Pulmonary Hypertension

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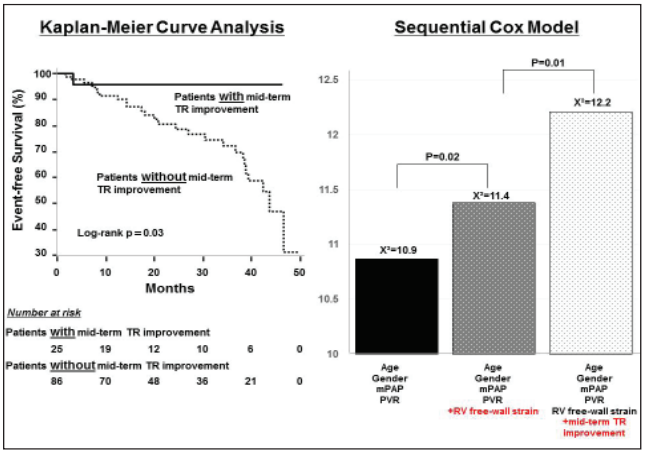
Background: The prognosis of pulmonary hypertension (PH) patients is difficult to estimate because various factors are complicatedly involved. It is recently reported that tricuspid regurgitation (TR) is highly associated with prognosis in various heart diseases, but its association with PH patients remain unclear. **Methods:** We studied 111 PH patients with age: 64±16 years, 75% female, left ventricular ejection fraction: 68±9%, and mean pulmonary artery pressure (mPAP) by right heart catheterization: 32±12 mmHg (all≥25mmHg). Mid-term follow-up echocardiography was performed 7.1 months after PH-specific treatment. RV function was calculated by averaging the three peak speckle-tracking longitudinal strains from RV free-wall (RV free-wall strain). According to the current AHA/ACC guideline, the severity of TR was graded as none or trace, mild, moderate, or severe. Mid-term improvement TR was defined as an increase in severity of TR by a grade of 1 or more. Long-term unfavorable outcome events were pre-specified as primary end points of death or hospitalization for deteriorating right-sided heart failure for 50 months. **Results:** Mid-term TR improvement after PH-specific treatment was observed in 25 patients (23%), and the primary end points occurred in 27 patients (24%). The Kaplan-Meier curve indicated that patients with more than moderate baseline TR showed unfavorable long-term outcomes than those without (log-rank p=0.008). Furthermore, patients with mid-term improvement TR showed favorable long-term outcomes than those without (log-rank p=0.03). For sequential Cox models for the prediction of long-term outcomes, a model based on clinical variables including age, gender, mPAP, and pulmonary vascular resistance (PVR) ($\chi2$=10.9) was improved by addition of RV free-wall strain ($\chi2$=11.4; p=0.02), and further improved by addition of the presence of mid-term TR improvement ($\chi2$=12.2, p=0.01), but not baseline more than moderate TR ($\chi2$=12.2, p=0.01). **Conclusion:** TR, especially mid-term TR improvement after PH-specific treatment was associated with long-term outcomes in PH patients. Therefore, the combined assessment of the parameters of RV performance and TR will result in more accurate prediction of long-term outcome, and may well have clinical implications for better management of PH patients.



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P1-144

The Extent of Mitral Annular Disjunction in Barlow Disease: Comparison Between Late Systolic and Holosystolic Prolapse

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Background: Mitral annular disjunction (MAD) is a common anatomic abnormality in mitral valve prolapse (MVP).MVP typically occurs as late systolic or holosystolic prolapse, which affect the amount and severity of mitral regurgitation. Little is known regarding the association between the extent of MAD and the duration of MVP in Barlow disease. **Methods:** Twenty-three consecutive patients with Barlow disease were studied using real-time 3D transesophageal echocardiography (3DTEE). Patients were divided into two groups: 12 patients with late systolic prolapse and 11 patients with holosystolic prolapse. The circumferential extent and the distance of MAD were quantified using 3DTEE datasets of the annulus. MAD index was defined as the product of MAD arc degree and distance. The rate of systolic expansion of mitral annulus area was calculated as (maximal mitral annulus area in systole - end-diastolic mitral annulus area) / end-diastolic mitral annulus area. **Results:** The patients with late systolic prolapse had significantly greater circumferential extent of MAD (180±39 vs 51±28 degree, P<0.001), MAD distance (7.4±3.3 vs 5.0±1.8 mm, P=0.039) and MAD index (1388±690 vs 269±179 mm•degree, P<0.001) compared with patients with holosystolic prolapse. The rate of systolic expansion of the mitral annulus was positively correlated with MAD index (P=0.038). **Conclusions:** MAD is highly prevalent in patients with late systolic MVP. The extent of MAD may affect systolic expansion of the mitral annulus and the duration of MVP in Barlow disease.

P1-145

The Continuum of Severe Tricuspid Regurgitation: Severe and Super Severe?

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Background: According to recent valvular regurgitation guidelines, tricuspid regurgitation (TR) vena contracta (VC) of >0.7 cm identifies severe TR. However, VCs of >0.7 cm are commonly seen in clinical practice and therefore we hypothesized that a category of "super severe" TR may exist that would have greater adverse remodeling of right ventricle (RV) and worse prognosis compared to patients with "severe TR". Accordingly, we sought to assess the relationship between tricuspid annulus (TA) diameter, RV size and function with mortality over a wide spectrum of severe TR. **Methods:** We studied 105 patients (71±17 years) with severe functional TR (VC >0.7 cm) defined by the average of measurements performed in the RV inflow and apical 4-chamber views, including 74 patients with 3D full-volume datasets of the RV (Philips). Patients were divided into tertiles of VC (0.70-0.82 cm, 0.82-0.91 cm, ≥0.91 cm). TA, RV end-diastolic base (RVEDb), mid (RVEDm) and length (RVEDL) dimensions and RV free wall strain (FWS) were measured. 3D RV volumes and EF were measured. Mortality data over 6 years was obtained from the electronic medical records. Comparisons between groups were performed using ANOVA. Mortality data was compared with Fisher's exact test. **Results:** Increasing severity of VC width was associated with increased TA size, TV tenting, RVEDb, RVEDm, RVEDL dimensions and 3D RV volumes. While, RV FWS worsened with increasing VC, 3D RVEF did not. There was a trend towards increased mortality with higher VC: 30%, 34%, and 47%, in the three tertiles, respectively (p=0.15). **Conclusions:** There is a continuum within the diagnosis of severe TR associated with progressive TA dilatation and more advanced adverse RV remodeling tending towards worsening prognosis. Further stratification of severe TR based on further VC partitions can identify patients at higher risk for adverse remodeling and may predict worse outcomes.

	TR VC ≤0.82	TR VC 0.82-0.91	TR VC >0.91	p
Age (yrs)	72 ± 17	67 ± 19	73 ± 15	0.34
VC (cm)	0.75 ± 0.04	0.87 ± 0.03	1.13 ± 0.29	<0.001
TV tenting (cm)	0.76 ± 0.34	0.94 ± 0.36	1.02 ± 0.30	0.008
TV annulus (cm)	4.1 ± 0.5	4.3 ± 0.6	4.9 ± 0.6	<0.001
RV base (cm)	5.1 ± 0.8	5.5 ± 0.9	6.2 ± 0.8	<0.001
RV mid (cm)	3.9 ± 0.9	4.5 ± 1.1	5.0 ± 1.0	<0.001
RV long axis (cm)	7.8 ± 1.1	8.6 ± 1.0	8.7 ± 1.1	0.001
RV free wall strain (%)	-16 ± 6	-13 ± 5	-12 ± 4	0.001
3d EDVi (ml/m2)	158 ± 65	175 ± 49	213 ± 59	0.005
3d ESVi (ml/m2)	97 ± 45	112 ± 43	136 ± 42	0.009
3d RVEF (%)	39 ± 10	38 ± 11	37 ± 9	0.77

P1-146

Improved Outcomes of Biventricular Repair in Straddling Atrioventricular Valves in the Current Era

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Background: Straddling atrioventricular (AV) valves are rare congenital cardiac malformations that have been recognized as a limiting factor for successful biventricular (BIV) repair. Recent refinements in surgical techniques have contributed to the successful application of biventricular repair in select patients, especially the ones with minor straddling, but there is a paucity of data on factors associated with successful biventricular repair in the current era. The goals of this study, therefore, are to describe the characteristics and outcomes of patients with straddling AV valve who undergo a biventricular repair and to identify risk factors associated with poor outcomes. **Methods:** A retrospective review identified 38 patients with straddling AV valves who underwent biventricular repair surgery between 1985 and 2017. A detailed review of the echocardiograms, surgical reports and all pertinent records was undertaken. **Results:** The median age at biventricular repair was 9 months (2 days to 165 months). There were 25 (66%) males. Twenty-six patients (68%) had straddling tricuspid valve, and 12 (31%) had straddling mitral valve. Major straddle was seen in 23 patients (60%). Conotruncal abnormalities were common (28 patients, 73%). After repair, there were 6 deaths (16%) within 30 days of surgery and no late deaths at a median follow-up among survivors of 3.6 months (6 days-170 months). Seven patients (18%) required a total of 12 surgical reinterventions, of which 4 were AV valve reinterventions. As shown in the figure, survival was significantly better in patients operated after the year 2000 versus before 2000 (p<0.001). There was no difference in survival between straddling mitral versus tricuspid valves (p=0.25). Younger age at repair and smaller weight at repair were associated with moderate or greater AV regurgitation at follow-up (p= 0.008 and 0.02, respectively). **Conclusions:** Although mortality rates were previously high, in the current era BIV repair is feasible even with major AV straddle with low mortality rates. Younger age and smaller size at repair are associated with moderate or greater AV regurgitation at follow up.

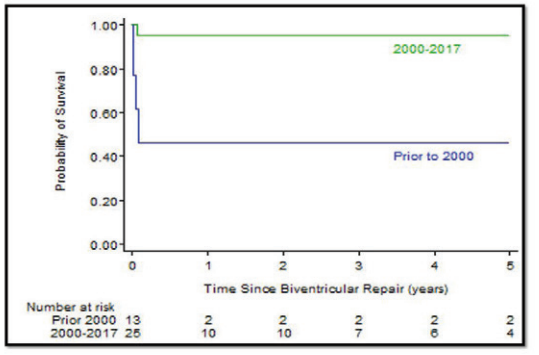

Figure: Kaplan-Meier curve showing the probability of survival of patients with straddling AV valves operated before and after the year 2000 (p<0.001).

P1-147

Revisiting the Relationships Between Bicuspid Aortic Valve and Aortopathy: Insights from a Large Community Cohort

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Background: Bicuspid aortic valve (BAV) is the most common congenital heart defect and is frequently associated with aortapathy. Both hemodynamic (aortic dilation resulting from shear stress of diseased valve) and genetic (aortic dilation from genetic abnormality independent of BAV disease progression) have been postulated to explain the relationship between BAV and aortapathy. We evaluated these relationships in a large community cohort. **Methods:** We queried all echocardiograms with diagnosis „bicuspid aortic valve" at Aurora Health Care, an integrated health system with 33 inpatient and outpatient echocardiographic laboratories. We reviewed all echocardiograms to confirm diagnosis of BAV. The ascending aorta was measured and indexed to body surface area. Aortapathy, if present, was defined as type 1 (primary aortic root dilation), type 2 (primary dilation of ascending aorta distal to sinotubular junction) and type 3 (diffuse dilation of aortic root and ascending aorta). Additional clinical and echocardiographic

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variables were collected. **Results:** We identified 1257 BAV patients in our community cohort, mean age 52 ± 16.2 years and 842 (67.0%) were male. Of these, 765 (60.1%) had aortapathy. Patients with aortapathy were older (mean 54.8 ± 14.7 vs. 52.7 ± 18.1 years, p=.03), had higher body surface area (2.14 ± 0.42 vs. 2.0 ± 0.31 kg/m^2 p=.015), and were more likely to be male (OR 1.92 [95% CI 1.51-2.45, p<.001). Aortapathy patients were also more likely to have right-left cusp fusion (80.7% vs. 68.0% p <.001), higher aortic velocity (1.41 ± 1.2 vs. 1.0 ± 1.2 m/sec, p<.001), and more likely to have aortic regurgitation (77.5% vs. 69.0% p = .0009). There were no differences in presence of raphe, presence of aortic stenosis and leaflet calcification between the two groups. All types of BAV fusion were noted in all the types of aortapathy. Of note, in our series, 191 patients with aortapathy had normal functioning BAV (no aortic stenosis and none/trace AI). **Conclusions:** Aortapathy is frequently present (60.1%) in a large community series of BAV patients. Clear clinical and echocardiography characteristics emerge to differentiate BAV patients with aortapathy. However, the relationships between aortapathy and BAV are complex, and likely not explained by any single theory on etiology. Longitudinal follow-up of this large community cohort has the potential to add clinical insight into mechanisms of BAV aortapathy.

P1-148

Predictor of Persistent Tricuspid Regurgitation After Transcatheter Aortic Valve Replacement

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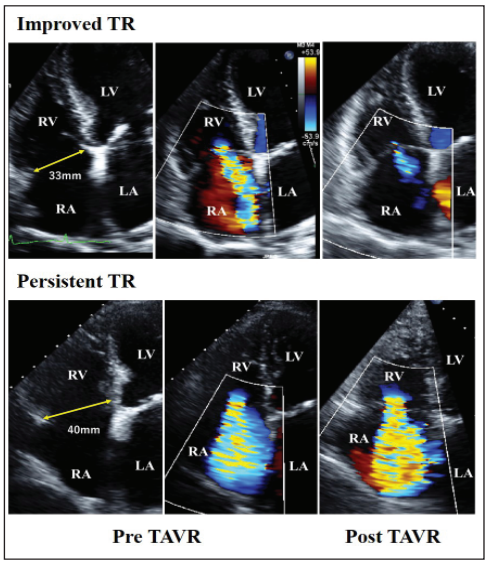
Background: Persistent tricuspid regurgitation (TR) is considered to increase mortality in patients with aortic stenosis undergoing surgical aortic valve replacement. The aim of this study was to investigate clinical and echocardiographic determinants of persistent TR after transcatheter aortic valve replacement (TAVR). **Methods:** We reviewed 1091 patients who underwent TAVR in our institution between January 2014 and January 2017. Among them, 100 patients had moderate or more TR before TAVR. Before and follow up echocardiography after TAVR were analyzed (median follow up period was 386 days). TR severity was graded based on ASE guideline. Right atrial area, right ventricular (RV) areas, RV fractional area change, tricuspid valve (TV) annular dimension, and TV tethering height were measured in the apical 4-chamber views. RV systolic pressure was calculated using the simplified Bernoulli equation. **Results:** Among patients with significant TR before TAVR, 48 (48%) patients had improved TR, while 52 (52%) patients had persistent TR (unchanged in 43 patients (43%) and worsened in 9 patients (9%)). At baseline, the prevalence of atrial fibrillation (AF) was higher in persistent TR patients compared to improved TR patients (40 vs. 73 %, p = 0.001). Compared to patients with improved TR, patients with persistent TR had a larger TV annular dimension, RV areas, and right atrial area (p < 0.05 for all), while there was no significant difference in RV fractional area change, TV tethering height, and systolic RV pressure between 2 groups. In univariate analysis, persistent TR after TAVR was significantly related to the prevalence of AF (Odds ratio = 4.1, p = 0.001), TV annular dimension (Odds ratio = 1.2, p < 0.001), and RV end-diastolic area (Odds ratio = 1.1, p = 0.03). In multivariate analysis, the prevalence of AF (Odds ratio = 2.9, p = 0.03) and TV annular dimension (Odds ratio = 1.1, p = 0.02) were the only independent predictors of persistent TR. Receiver operating characteristic curve showed that cut-off value of TV annular dimension of >38mm had optimal sensitivity and specificity in predicting persistent TR after TAVR. **Conclusion:** The presence of AF and TV annular enlargement in patients with aortic stenosis are the independent predictors of persistent TR after TAVR.



P1-149 Moderated Poster

Virtual Reality Using 3D Echocardiography to Evaluate Structural Heart Disease

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Background: 3D echocardiography (3DE) is increasingly utilized in guiding structural heart disease interventions involving the mitral valve (MV). 3DE data can be visualized using shading and surface/volume rendering to create the appearance of a 3D structure on a flat screen. 3D printing is also increasingly used to create patient specific physical 3D models for surgical planning, but the printing and post-processing can be time-consuming and expensive. Virtual reality (VR) is a new technique that allows true 3D visualization and interaction with 3D datasets using commercial VR headsets and controllers. To incorporate 3D printing and VR into the evaluation of structural heart disease, the ability to provide accurate measurements is important. The aim of this study was to determine the accuracy of MV measurements made in a VR environment and on a 3D printed models, using 3D multiplanar reconstruction (MPR) as the reference standard. **Methods:** Six high-quality 3D transesophageal (TEE) datasets of the MV with varying pathologies were converted using a novel, custom software into VR environments with 3D surface models. A novel prototype VR environment was developed that allows the user to load, interact and measure these models in real time using a VR headset (HTC VIVE). Each 3D MV model was also printed using a 3D printer (Statasys Connex3). Blinded measurements of MV annular dimensions and area/circumference were performed with VR, 3D printing, and MPR at the same phase of the cardiac cycle. **Results:** All (6/6) 3D TEE datasets were successfully converted into 3D models compatible with the VR environment and the 3D printing process (Figure). Measurements of the MV annulus, area, and circumference using VR and MPR showed excellent inter-technique agreement (Table). Measurements made on 3D prints agreed well with MPR but had greater variability. **Conclusion:** This is the first study to demonstrate excellent agreement between measurements performed in a VR environment using 3DE based models and MPR. Using a VR environment to analyze and measure 3DE based models is a promising new tool to plan and guide structural heart disease intervention that offers the advantage of true 3D visualization and interaction. Further studies evaluating the role for VR in planning structural heart interventions are warranted.

P1-150

Development and Prognostic Validation of Partition Values to Grade Right Ventricular Dysfunction Severity With Three-Dimensional Echocardiography

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Background: Transthoracic three-dimensional echocardiography (3DE) has been shown to be feasible and accurate to measure right ventricular (RV) ejection fraction (EF) when compared to cardiac magnetic resonance (CMR). However, RVEF, either measured with CMR or 3DE, has always been reported as normal (RVEF> 45%) or abnormal (RVEF≤45%) without being able to further stratify RV dysfunction in mildly, moderately or severely reduced as we are used to do with the left ventricle. **Methods:** We used 3DE to measure RVEF in 412 consecutive patients (55±18 years, 65% men) with various cardiac conditions who were followed for 3.7±1.4 years to obtain the cut-off values which defined mild, moderate and severe reduction of RVEF (derivation cohort). Then, the prognostic power of these cut-off values was tested in an independent population of 446 patients (67±14 years, 58% men) studied at the University of Occupational and Environmental Health (Japan) (validation cohort). **Results:** During follow-up, we recorded 59 deaths (14%) in the derivation cohort. We used the K-Adaptive partitioning for survival data algorithm to identify 3 groups of patients with significantly different mortality according to RVEF: 40.9%<low≤46%, 32.1%<moderate≤40.9%, and high≤ 32.1% RV dysfunction. To make the cut-off values simpler, we approximated them to 45%, 40% and 30%. During 4.1±1.2 years follow-up, 38 cardiac deaths and 88 MACE (cardiac death, non-fatal myocardial infarction, ventricular fibrillation or admission for heart failure) occurred in the validation cohort. The cut-off values of RVEF identified in the derivation cohort were able to stratify both cardiac death (log-rank= 78.97; p<0.0001) and MACE (log-rank= 35.15; p<0.0001) in the validation cohort too (Figure). **Conclusions:** Our results confirm the prognostic power of RVEF in patients with heart diseases and identify the cut-off values of RVEF to stratify the risk of cardiac death and MACE.

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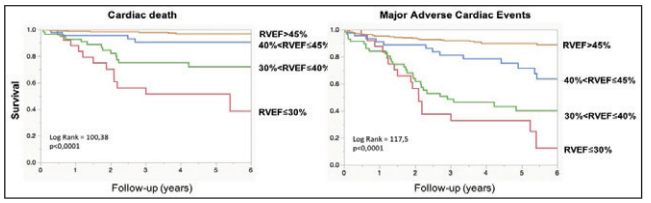

P1-151

Exercise-Induced Changes in Right Ventricular Mechanical Pattern: New Marker of Athlete's Heart?

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Background: Exercise-induced cardiac remodeling, also known as the athlete's heart, is a well-described phenomenon. Although, it usually includes dilation of all four cardiac chambers, there is a growing evidence that intense endurance training puts disproportionally high burden on the right ventricle (RV). Accordingly, we investigated the alterations in RV mechanics of young, elite athletes using 3D echocardiography. **Methods:** Sixty water polo athletes (19±4 years, 30 females, 30 males) and 40 age and gender matched untrained, healthy controls were enrolled. Detailed medical history and training regime were obtained followed by physical examination, cardiopulmonary exercise testing and 3D echocardiography. After reconstruction of the beutel model of the RV, 3D RV global longitudinal strain (GLS) and global circumferential strain (GCS) were calculated with our custom MATLAB software. We also quantified longitudinal and radial ejection fraction (EF) by decomposing the motion of the RV using the ReVISION method. **Results:** All enrolled athletes participated in competitive sport for an average of 10 years with a mean training time of 17 hours/week. As expected, left ventricular (LV) and RV end-diastolic volume were higher in athletes (athletes vs control, LV end-diastolic volume: 176±36 vs 116±19mL, RV end-diastolic volume: 174±37 vs 112±17mL, both p<0.001) along with increased LV mass (194±44 vs 113±22g, p<0.001), while both LV and RV EF were lower compared to non-trained individuals (LV EF: 57±5 vs 62±3%, RV EF: 56±4 vs 61±5, both p<0.001). GLS was found to be similar between the groups (-20±3 vs -20±4%), however, GCS was significantly lower in athletes (-19±3 vs -23±5%, p<0.001). A prominent functional shift was observed in the relative contribution of longitudinal and radial motion to global RV function in athletes, as longitudinal EF/ total EF ratio was significantly higher (0.50±0.07 vs 0.43±0.07 ,p<0.001), whereas radial EF/ total EF was lower (0.33±0.08 vs 0.45±0.08, p<0.001) compared to controls. Moreover, the degree of this functional shift correlated with peak oxygen uptake (longitudinal EF vs VO2/kg: r=0.30, p=0.024; radial EF vs VO2/kg: r=-0.27, p=0.043). **Conclusion:** As part of the adaptive remodeling seen in athletes, a functional shift could be observed in the contribution of different components to global RV function. The increased relative contribution of RV longitudinal contractions (along with a decreased radial motion) correlated with peak aerobic performance measured by cardiopulmonary exercise test. This mechanical pattern may be an important marker of athlete's heart.

P1-152

Stereo Display of Three-Dimensional Echocardiography Improves Appreciation of Simple and Complex Cardiac Structures Compared to Conventional Non-Stereo Display

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Background: Three-dimensional echocardiography (3DE) is increasingly utilized as an important adjunct to conventional echocardiogram in pre-operative planning for both simple and complex cardiac lesions. However, most 3DE are reviewed on two-dimensional displays (non-stereo) and negates the encoded true depth spatial data (stereo) in 3DE. We hypothesize that 3DE viewed on a stereo display improve understanding of cardiac structures and spatial relationships of complex anatomy when compared to conventional non-stereo display. **Methods:** Using proprietary software capable of rendering full volume 3DE (up to 69 Hz) in high resolution stereo and non-stereo display, we compared the experience of 7 users (cardiologists, trainees and surgeons) viewing 10 3DE of alternating 5 simple and 5 complex cardiac lesions. In Part A, 3DE was randomized to either 1 min of stereo followed by 1 min of non-stereo or vice versa. Part B is 90 secs where users are able to toggle between stereo and non-stereo display. The users subjectively rated their experience on Likert scale (1=strongly disagree to 5= strongly agree) on 4 statements on each 3DE. The study was designed in conjunction with an education researcher to minimize biases by randomization, staggered simple and complex 3DE to minimize learning effect, and use of oppositionally positioned statements. Users were unaware of objective data logged such as time spent in each display and the degree of 3DE manipulation. **Results:** Stereo displays were consistently rated better than non-stereo in improving appreciation of cardiac anatomy (Likert 4.0±0.4 vs 2.3±0.4, P<0.0001). Similar benefit was equally appreciated between simple and complex 3DE (Likert 4.0±0.4 vs 4.0±0.5, P=0.91). Users preferentially spent more time in stereo in Part B (58±10 vs 32±10 s, P<0.0001) and notably longer stereo time was spent in complex 3DE (59.9±9.5 vs 55±10.9 s, P<0.0001). Manipulation of 3DE as degree of rotation per second (deg/s) was greater in Part A non-stereo (55±12 vs 54±16 deg/s, P<0.0001) and greater during Part B stereo (67±33 vs 59±18 deg/s, P<0.0001). Manipulation was greater in stereo display of complex 3DE in both Part A (58±18 vs 53±15 deg/s, P<0.0001) and Part B (71±24 vs 63±37 deg/s, P<0.0001). **Conclusions:** Stereo projections of 3DE improved appreciation of cardiac structures and were helpful in simple and complex lesions. Users objectively showed a preference for stereo projections when reviewing complex lesions by logging greater time and manipulation.

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3D Echocardiographic Automated Quantification of Left Ventricular and Left Atrial Time-Volume Curves: Comparison with MRI

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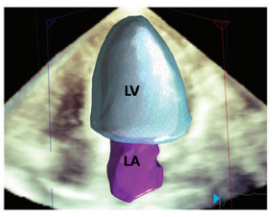
Background: Compared to 2D echocardiography (2DE), 3D echocardiography (3DE) has been shown to be more accurate and reproducible for determination of left ventricular (LV) and left atrial (LA) volumes. However, dynamic 3DE LV and LA volumes are currently not routinely measured due to the lack of specialized software and the lengthy time required for analysis of multiple time frames. The first 3DE adaptive analytics algorithm for automated simultaneous determination of dynamic LV and LA volumes was recently developed. We aimed to test the accuracy of this algorithm by comparing it to the reference standard of cardiac MRI (CMR). **Methods:** Twenty consecutive patients (60% female), referred for a clinical CMR, prospectively underwent 3DE (Philips EPIQ with an X5-1 transducer) and CMR imaging (Philips 1.5 T scanner) on the same day. Single-beat, high-frame rate 3DE data sets were acquired to include both the LV and LA. Time-volume curves were automatically derived for both chambers using 3DE automated software (Philips HeartModel; **left figure**) and CMR (frame-by-frame manual tracing in short axis slices encompassing the entire chamber). LV and LA systolic and diastolic volumes and filling/ejection parameters were extracted from the time volume curves and compared between modalities. **Results:** Minor manual correction of the automatically detected LV and LA borders was performed in 4/20 and 5/20 cases, respectively. Time required for generation of time-volume curves from 3DE (including manual correction) was significantly shorter compared to CMR (0.6±0.3 vs 96±14 minutes, P<0.0001). Time-volume curves obtained from 3DE and CMR were similar in shape and magnitude in the majority of patients (**right figure**). Chamber size and function parameters extracted from these curves showed excellent agreement with no significant inter-modality differences **(Tables). Conclusion:** Automated 3DE software for dynamic LV and LA volume measurement allows fast and accurate analysis of ejection and filling parameters, when compared to CMR without the need for manual correction in the majority of cases. Incorporation of this algorithm into clinical workflow may provide additional insight into abnormalities in cardiac function that are not assessable by current echocardiographic techniques.



	Left Ventricle	CMR	Heart Model
Ejection Indices	End-systolic volume	76 ± 25	69 ± 21
	Stroke volume	100 ± 22	98 ± 23
	Ejection fraction	58 ± 9	59 ± 7
	Volume (50% ejection time)	123 ± 32	108 ± 29
Filling Indices	End-diastolic volume	175 ± 36	167 ± 36
	Filling duration (%RR)	61 ± 7	57 ± 4
	Volume (25% filling time)	101 ± 35	91 ± 26
	Volume (50% filling time)	136 ± 40	123 ± 26
	Volume (75% filling time)	148 ± 40	141 ± 39
	Volume at diastasis	145 ± 41	133 ± 32
	Rapid filling volume	69 ± 27	64 ± 18
	Rapid filling fraction	0.68 ± 0.17	0.65 ± 0.11
	Atrial filling volume	31 ± 15	34 ± 13
	Atrial filling fraction	0.32 ± 0.17	0.35 ± 0.11

	Left Atrium	CMR	Heart Model
Filling Indices	Maximum volume	86 ± 24	81 ± 25
	Filling duration (%RR)	45 ± 10	46 ± 7
	Filling fraction	49 ± 11	56 ± 12
	Volume (50% filling time)	68 ± 24	59 ± 22
Emptying Indices	Minimum volume	45 ± 24	36 ± 18
	Emptying duration (%RR)	55 ± 10	54 ± 7
	Volume (25% emptying time)	74 ± 26	67 ± 18
	Volume (50% emptying time)	68 ± 22	56 ± 18
	Volume (75% emptying time)	65 ± 22	52 ± 18
	Volume at diastasis	66 ± 22	55 ± 21
	Passive emptying volume	20 ± 9	26 ± 10*
	Passive emptying fraction	0.49 ± 0.21	0.58 ± 0.14
	Active emptying volume	21 ± 11	19 ± 8
	Active emptying fraction	0.51 ± 0.21	0.42 ± 0.14

* p<0.05

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Change of Mitral Leaflet Geometry Causes Functional Mitral Regurgitation without Significant Mitral Valve Tethering: A Three-Dimensional Transesophageal Echocardiography Study

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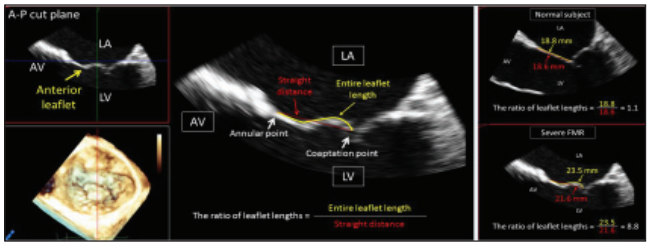
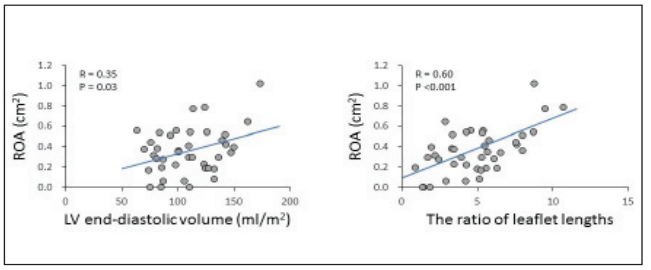
Background: Mitral valve (MV) tethering plays a central role in the development of functional mitral regurgitation (FMR). However, patients with FMR without MV tethering were encountered in clinical setting. Chronic atrial fibrillation with left atrial dilatation has been known to cause FMR. Therefore, we aimed to investigate FMR without MV tethering in patients with sinus rhythm using 3-dimensional transesophageal echocardiography (3D TEE). **Methods:** We studied 40 FMR patients with sinus rhythm and left ventricular (LV) dysfunction (ejection fraction <50%) but without significant MV tethering, defined as a tenting height ≤7.7 mm. Control subjects with normal MV (n = 28) had tenting of 4.9 ± 1.4 mm. The value of 7.7 mm was derived from the mean plus 2 standard deviation. LV volumes were evaluated using biplane disks method. MV annular dimensions, MV annular area, MV tenting height and volume, and MV leaflet area were evaluated using 3D TEE datasets. The ratio of the entire anterior leaflet length to straight distance from annular point to coaptation point was also determined to assess the change of leaflet geometry, which represented an inappropriate mitral leaflet remodeling (Figure 1). Regurgitant orifice area (ROA) was measured assuming elliptical shape of the flow convergence zone by 2D color Doppler. **Results:** Compared to controls, FMR had larger LV volumes, annular area, tenting volume, and leaflet area (P<0.01). The ratio of leaflet lengths was also greater in FMR patients compared with controls (4.9 ± 2.4 vs. 2.3 ± 1.7, P <0.01). A wide range of ROA (0.02 to 1.02 cm^2) was observed, unrelated to LV ejection fraction. ROA was correlated with LV end-diastolic volume and the ratio of leaflet lengths (Figure 2). The primary determinant of ROA was the ratio of leaflet lengths (β = 0.6, P <0.01) after adjustment of LV volumes and MV 3D parameters. **Conclusion:** Inappropriate leaflet remodeling contributed to the severity of FMR in patients without significant MV tethering or atrial fibrillation, independent from LV remodeling.





P1-155

Geometry of Tricuspid Valve Revisited: Visualization by Transesophageal Echocardiography with Trans-Gastric Approach

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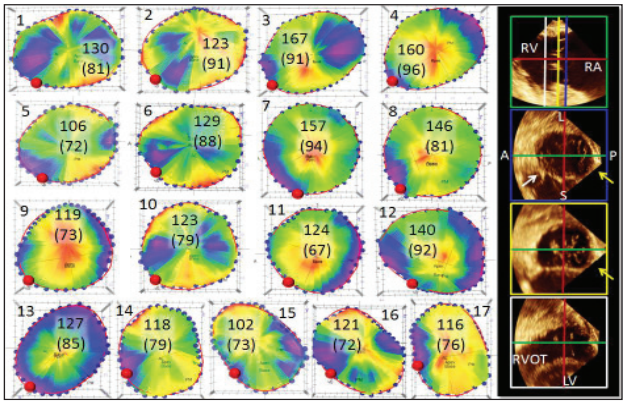
Background: Tricuspid annulus dilates anteriorly and posteriorly, corresponding to the free wall of the right ventricle. The purpose of this study is to revisit the geometry of tricuspid valve in functional tricuspid regurgitation (TR) with using optimal imaging. **Methods:** 17 patients who underwent annuloplasty for functional TR were studied. Preoperative 3D volume data of tricuspid valve was acquired by transesophageal echocardiography (TEE) with trans-gastric approach. In the analysis, annular plane was extracted by MPR method and then A-P line (green line, figure) was carefully placed along anterior-septal commissure (AScom) to septal-posterior commissure (SPcom) direction. The commissures was recognized in the optimal MPR annular plane movie image and also the aortic valve commissure between non and right coronary cusp was referred for the identification of AScom (white arrow) and posterior interventricular sulcus (yellow arrow) for SPcom. L-S line was placed perpendicular line to A-P line. The intersection of the 2 lines was placed on the center of the annulus. 3D analysis software (Real View) was used for the reconstruction of the mid systolic configuration. **Results:** Reconstructed tricuspid annulus and leaflet were shown in the figure, displaying the A-P line in a horizontal and L-S line in a vertical direction. Leaflets were colorized by bluish for higher points and reddish for lower points from right atrial perspective. Red dot indicates the point of AScom. The number on each image indicates annular perimeter with the standardized perimeter with BSA in a parenthesis (mm). Case 1-6 and 13 showed typical geometric change as literatures demonstrate. Case 7-11 showed more circular annulus than the former ones. In case 14-17, dilatation towards anterior rather than posterior direction was observed with relatively smaller perimeter compared to the other cases. **Conclusions:** By using 3D TEE dataset with transgastric approach, polymorphic geometry in tricuspid annulus and leaflet could be visualized. Our results suggest the valve geometry varies, probably depending on the degree of the annular dilatation and also on the morphologic change in the adjacent chambers and vessels. This finding may have clinical implications for selecting a strategy in tricuspid valve repair. Further study with large number is need.



P1-156

Predictive Impact of Mitral Apparatus Dynamics on the Improvement of Ischemic Mitral Regurgitation after Acute Myocardial Infarction: Four-Dimensional Quantitative Echocardiographic Study

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Background: Although acute ischemic mitral regurgitation (IMR) is known to worsen the short-term and long-term prognosis after acute myocardial infarction (AMI), degree of acute IMR can improve dramatically after percutaneous coronary intervention (PCI). We sought to evaluate the predictive value of acute stage mitral valve apparatus geometry and dynamics for the reduction of IMR in the remote phase after successful primary PCI by using real-time transthoracic 3D echocardiography. **Methods:** We performed 2D and 3D echocardiography in consecutive 44 first acute MI patients with more than mild IMR within 3 days after successful primary PCI. 3D echocardiography of LV volumes and mitral apparatus dynamics through the cardiac cycle, such as annulus area, leaflet tenting length and papillary muscles spatial positions were quantified offline using custom software. We compared the 3D geometric and dynamic parameters in the acute phase between 1) 20 remained MR group and 2) 24 improved MR group in 6 to 12 months after MI onset. **Results:** LV end diastolic volume in the acute phase was similar between the remained MR and the improved MR group (139.3±31.8 vs. 134.8±35.2mL, p=0.657). LV ejection fraction (LVEF) was preserved in improved MR group compared to the remained MR group (49.0±11.2 vs. 56.5±7.0%, p=0.013). Mitral valve annulus area, leaflet tenting length and papillary muscles spatial position had no significant difference between the two groups (all p>0.05) throughout cardiac cycle. In contrast, mitral annulus saddle shape was preserved in the improved MR group than the remained MR group (annular height/intercomissure diameter ratio 13.3±3.9 vs. 16.4±3.6%, p=0.010) and annular area changed dynamically through early- to late-systole in the improved MR group (phasic p=0.017) despite it was adynamic in remained MR group (phasic p=0.201)(Figure). **Conclusions:** Patients with IMR improvement in the remote phase after AMI had more preserved LVEF, mitral annulus saddle shape and dynamics during systole in the acute phase of MI, compared to those with remained IMR . 4D dynamics of the mitral apparatus can be clinically useful predictor of the improvement in acute IMR, and may contribute to the clinical decision making including surgical or percutaneous intervention for the IMR which conveys the adverse prognosis after AMI.

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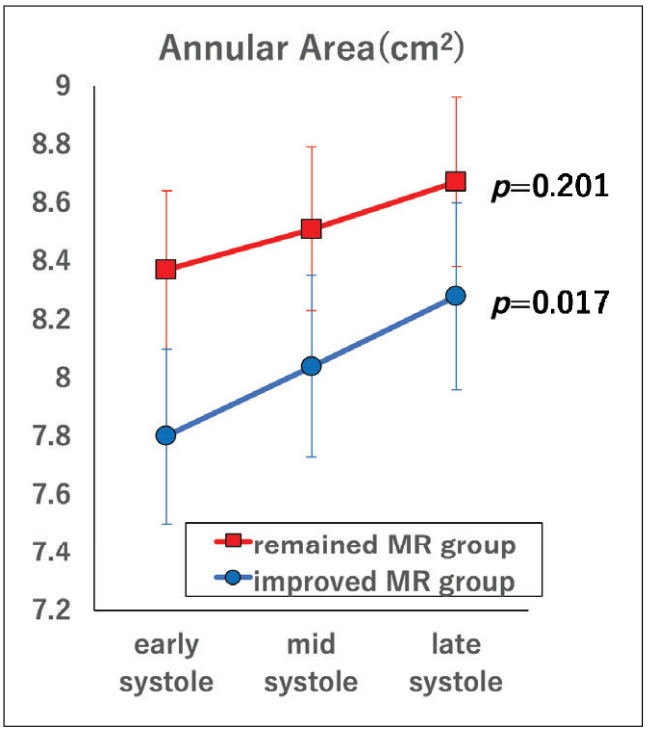

P1-157

Left Atrial Appendage Remodeling and Function in Atrial Fibrillation: Insight from 2D, 3D, and Doppler Echocardiography

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Background: The left atrial appendage (LAA) is a common source of systemic embolism in patients with atrial fibrillation (AF), but LAA remodeling in the setting of AF is not well defined. We sought to define LAA remodeling in a group of patients with paroxysmal vs persistent AF. **Methods:** We retrospectively identified 29 patients with a history of AF that underwent transesophageal echocardiography for AF catheter ablation or LAA occlusion. Quantitative 3D measurements were performed with TomTec 4D software (Unterschleissheim, Germany) and 2D-Doppler measurements were performed retrospectively using available images. **Results:** All patients had a history of AF; 15 patients were in sinus rhythm at time of the procedure (paroxysmal AF) and 14 patients were in AF (persistent AF). Demographics and echocardiographic characteristics according to type of AF are shown in the Table. Patients with persistent AF had larger ostial LAA area, larger LAA volume, and lower LAA 3D ejection fraction and fractional area change as measured by 3D echocardiography. Maximum ostial diameter in paroxysmal vs persistent AF were not statistically different by 2D echocardiography. Mid-left atrial appendage fractional area change by 3D echocardiography correlated well with peak Doppler ejection velocity (r^2=0.73, p<0.0001) and modest correlation was observed between 3D volumetric ejection fraction and Doppler ejection velocity (r^2=0.32, p=0.009). **Conclusion:** Patients with persistent AF, compared to paroxysmal AF, have more significant LAA eccentric remodeling with abnormal systolic function and this was appreciated by 3D but not 2D echocardiography. This data may have future implications in risk stratification for cardioembolism and LAA sizing prior to percutaneous LAA occlusion.

Table: Baseline and echocardiographic characteristics of the patients

	Paroxysmal AF (n=15)	Persistent AF (n=14)	p
Age(yrs)	74(66-81)	78(65-81)	0.35
Female(n;%)	5(33)	3(21)	0.47
LAA maximum volume (ml)	10.0x(8.5-14.7)	15.6(11.2-18.9)	0.038
LAA minimum volume (ml)	6.3(5.1-7.9)	11.4(9.1-15.5)	0.0026
EF of the LAA (%)	40(33-54)	22(11-28)	<0.0001
3D Maximum Ostial Area (cm²)	2.61(2.08-3.92)	4.59(3.58-6.05)	0.0033
3D Ostial Diameter (mm)	17(14-20)	21(18-26)	0.0015
3D Ostial Diameter (mm)	20(18-24)	27(24-31)	0.01
3D Perimeter (mm)	58(53-73)	79(68-89)	0.0031
3D Length (mm)	27(23-32)	31(27-34)	0.1
Heart Rate (beats/min)	53(50-63)	69(63-75)	0.0019
3D maximum mid cross-sectional area (cm²)	1.81(1.53-3.06)	2.75(1.97-3.75)	0.088
3D minimum mid cross-sectional area (cm²)	0.92(0.4-1.25)	1.73(0.94-2.95)	0.0116
LAA mid LAA fractional area change (%)	58.3(44.5-69.5)	31.8(23.0-50.3)	0.0035
2D maximum ostial diameter (mm)	23.6(20.7-26.1)	27.1(22.8-28.8)	0.135
2D Length (mm)	31(26.1-33.5)	29(26.7-32.7)	0.9
Doppler velocity (cm/s)	59.5(37.25-81.75)	39.5(23-43)	0.0211

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The Correlation and Difference between Two-Dimensional and Three-Dimensional Strain -Comparison in Normal Children

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Background: Three-dimensional speckle tracking echocardiography (3DST) is methodologically superior to two-dimensional speckle tracking (2DST), because 3DST is free from through-plane artifact, which is one of the major drawbacks of 2DST. However, the volume rate of 3DST is usually lower than the frame rate of 2DST, which may make underestimation of the magnitude of peak strain. There are paucity of data comparing the differences of strain of the left ventricle (LV) between 3D and 2D in normal children. The objective of this study is to determine the correlation and difference between 3D and 2D in normal children. **Methods:** Eighty one normal children (male: 42; female: 39; age: median (range): 8.9 (4.7-15.7)) were included in this study. The full volume 3D data of LV were acquired in apical view with 4 heart beats, and the 2D data of LV were acquired in parasternal and apical views. The LV strain analyses of 3DST and 2DST were made off-line using 4D LV-Analysis (TOMTEC) and 2D Cardiac Performance Analysis (TOMTEC), respectively. LV end-diastolic volume (LVEDV), LV end-systolic volume, and LV-EF were also analyzed in 3D and 2D data set. 3D-global longitudinal strain (3D-GLS), global circumferential strain (3D-GCS), global radial strain (3D-GRS), and 3D-twist were analyzed on 3D full-volume. 2DST data (2D-GLS, 2D-GCS, 2D-GRS, and 2D-twist) were also analyzed and compared with respective data of 3DST. **Results:** The volume rate of 3DST (33 (20-60)/sec) was significantly lower than the frame rate of 2DST (apical view: 65 (34-92)/sec (p<0.05); short axis view: 81 (45-118)/sec (p<0.05)). LVEDV showed significant correlation between 3D (55.2 ± 15.5 ml) and 2D (triplane) (56.9 ± 16.3 ml) (r=0.89, p<0.001). The correlation between 3D-GLS and 2D-GLS were weak (r=0.26, p<0.05), and the magnitude of strain were significantly small in 3D-GLS (3D-GLS: -23.9 ± 2.7 %; 2D-GLS: -25.5 ± 2.4 %, p<0.05). However, 3D-GCS and 2D-GCS, or 3D-GRS and 2D-GRS showed no significant correlations. There was no significant difference between 3D-GCS (-28.2 ± 2.7 %) and 2D-GCS (28.2 ± 8.0 %). On the other hand, 3D-GRS (42.8 ± 3.2 %) was significantly higher than 2D-GRS (33.0 ± 9.5 %) (p<0.05). There was no correlation between 3D-twist and 2D-twist, and 3D-twist (10.4 ± 12.1°) was significantly bigger than 2D-twist (5.1 ± 8.8°)(p<0.05). **Conclusion:** Although there was good correlation of LV volume between 3D and 2D, the strain or twist showed weak or no correlation. Because 2D-GCS, 2D-GRS, or 2D-twist is significantly influenced by translational motion of the heart, they showed no correlation with those of 3D.

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Right Atrial Pressure Estimates by 2D and 3D Inferior Vena Cava Measurements are Discordant and Influenced by Vessel Morphology

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Background: Right atrial pressure (RAP) and intravascular volume status are estimated by echocardiography with 2D imaging of inferior vena cava (IVC) diameter and collapsibility. 3D imaging can avoid misalignment and likely achieve more accurate length measurements. We sought to compare the concordance between RAP estimates obtained from 2D- and 3D-derived measurements and identify causes of discordance. **Methods:** 200 patients had 2D and 3D subcostal IVC imaging performed before and after inspiratory sniff. Images were acquired using Philips iE33 and EPIQ7 systems and analyzed using QLAB v10.3 (Andover, MA). RAP was categorized as normal, mildly elevated, or elevated according to 2015 ASE guidelines. The reference 2D diameter limit was 2.1 cm and corresponding 3D-derived cross-sectional major axis (2.7 cm) and minor axis (1.9 cm) limits were obtained by regression analysis. Collapsibility index (CI) was calculated along each 2D and 3D axis direction. Sphericity index (SI) was calculated as the ratio of minor to major axis lengths and IVCs were categorized as either spherical (SI ≥ 0.7) or elliptical (SI < 0.7). **Results:** 2D IVC diameter was 2.0 ± 0.6 cm, while 3D major and minor axes were 2.7 ± 0.7 cm and 1.9 ± 0.6 cm. 2D RAP category concordance with 3D major and minor axis RAP categories was 43% and 63% (see table). CI was different along 3D major (44 ± 19%) and minor axes (52 ± 21%; p< 0.001). The discrepancy between maximum 2D diameter and 3D major axis length was different for spherical (0.4 ± 0.4 cm) compared to elliptical IVCs (1.0 ± 0.6 cm; p<0.001). **Conclusions:** Echocardiographic 3D IVC imaging provided discordant RAP categorization in roughly half of the cases compared with standard 2D IVC imaging. Collapsibility differs along the major and minor axes of the IVC. Vessel sphericity influences the discrepancies between 2D and 3D measurements. Future studies including invasive RAP reference values would provide additional information on the accuracy of 3D imaging of IVC dynamics.

Estimated RAP Categories							
		3D Major Axis Derived			3D Minor Axis Derived		
2D Diameter Derived	RAP Category	Normal	Mildly Elevated	Elevated	Normal	Mildly Elevated	Elevated
	Normal	**15**	39	19	**56**	15	2
	Mildly Elevated	8	**25**	37	27	**35**	8
	Elevated	2	10	**45**	6	17	**34**
Concordance		85/200 = 42.5%			125/200 = 62.5%		

P1-160

Can 3D Echocardiography Replace Cardiovascular Magnetic Resonance in the Diagnosis of Arrhythmogenic Right Ventricular Cardiomyopathy?

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Background: The Taskforce Criteria (TFC) for the diagnosis of Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC) requires the combination of 2D echocardiography (2DE) and cardiovascular MRI (CMR) to detect the presence of global and segmental right ventricular (RV) abnormalities. Little is known about the diagnostic value of 3D echocardiography (3DE) in ARVC. The aim of this study was to assess whether a combination of 2DE and 3DE could substitute 2DE and CMR combination with similar diagnostic accuracy in patients with suspected ARVC. **Methods:** 39 subjects (59% males, 47±15 years, 41% with desmosomal mutations) with suspected or confirmed diagnosis of ARVC underwent evaluation of the RV with the use of CMR, 2DE and 3DE. 3DE and CMR were independently used to obtain RV volumes, ejection fraction and presence of segmental RV abnormalities. These studies were blindly classified as meeting none, minor or major criteria for ARVC in accordance with the 2010 TFC. Kappa statistics were used to assess the concordance between 2DE-CMR and 2DE-3DE diagnostic approaches. **Results:** Using the 2DE-CMR approach, patients were classified as follows: 5 not affected, 8 with possible, 9 with borderline and 17 with definite ARVC diagnosis. The evaluation of TFC criteria with the 2DE-3DE approach yielded a high degree of concordance with the standard of care (2DE-CMR approach, **k=0.93 with 95% CI: 0.84-1.0**) (Figure). There was complete agreement between the 2DE-CMR and 2DE-3DE approaches for individuals with definite ARVC diagnosis (n=17) and in individuals not affected by ARVC (n=5). Two patients with possible and borderline ARVC diagnosis using the 2DE-CMR approach were confirmed as definite ARVC with the 2DE-3DE approach. **Conclusions:** The use of 2D and 3D echocardiography allows bedside evaluation of patients with suspected ARVC, which is diagnostically comparable to that obtained using the traditional combination of 2DE-CMR. This information is particularly relevant for patients who cannot undergo CMR such as patients with ICDs.

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Three-Dimensional Transesophageal Echocardiography is an Attractive Alternative to Cardiac Computed Tomography for Aortic Annular Sizing, Systematic Review and Meta-Analysis

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Background: Transcatheter aortic valve replacement (TAVR) has become an established alternative to the surgical approach in high-risk patients with severe inoperable aortic stenosis. Determination of the size of the prosthesis is a crucial point of the procedure. As a result, accurate cardiac imaging modalities are the cornerstone of successful outcomes from TAVR. The evolution in the understanding of aortic root geometry has significantly changed the prior assumption of the circular aortic annulus and LVOT. Consequently, two-dimensional echocardiography became incapable of defining the exact prosthesis size and paved the way for the three-dimensional (3D) era. Currently, multi-detector computed tomography (MDCT) with contrast angiography is the standard pre-TAVR imaging technique. Observational studies have been conducted to correlate 3D trans-esophageal echocardiography (TEE) annular sizing to MDCT annular sizing. This pursuit of correlation stems from the targeted cohort with multiple comorbidities and renal impairment in particular. **Methods:** We performed a systematic review and meta-analysis to assess the correlation and agreement between 3D TEE and MDCT annular sizing. A literature search of EMBASE, PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus was conducted using relevant keywords. We included studies that compared the aortic annular sizing between 3D TEE and MDCT. Two authors independently screened search results for eligibility. We used the random-effect inverse-variance method to combine the mean differences and limits of agreements, and generic inverse-variance method to combine Pearson correlation coefficient. Heterogeneity was assessed by forest plots and measured by I-square and Chi-square tests. P values less than 0.05 were considered significant. **Results:** Thirteen studies were included in our analysis (N=1026 patients). There was strong linear correlation between 3D TEE and MDCT measurements of aortic annulus area (r =0.84, p <0.001), mean perimeter (r =0. 0.85, p <0.001), and mean diameter (r =0.80, p <0.001). Bland-Altman plots showed that 3D TEE mean values were smaller than those of MDCT for the aortic annular area (mean difference was -2.22mm2 with 95% limits of agreement -12.79 to 8.36). However, this difference is insignificant to impact clinical decision making. **Conclusion:** Measurements of the aortic annulus with 3D TEE were comparable to those obtained by MDCT. Thus making 3D TEE an attractive alternative for aortic annulus assessment before TAVR, with an added advantage of reduced cost, radiation and contrast exposure.

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Left Ventricular Volumetry in Children - Should Total Blood Volume Replace Other Measures as an Adequate Index to Correct for Organ Growth?

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Background: For indexation of chamber size measurements in pediatrics many index variables have been investigated. Height, weight and formulas including both, such as Body surface area (BSA) or Body mass Index (BMI) have been used but there is no gold standard defined yet. We wanted to test the hypothesis if total blood volume (TBV) is a superior index for cardiac growth as it is closely linked to the cardiovascular system. **Methods:** A cohort of 378 healthy subjects (Group I: 0-6 ys, unisex: n=130, Group II and III: 7-18 ys, female: n=124, male: n=124) underwent realtime three-dimensional echocardiography (RT3DE , IE 33 or Vivid E9, 4-6 subvolumes). Quantification of end-diastolic, end-systolic and stroke volumes (EDV, ESV, SV) using dedicated software (4D LV-Analysis 3.1 software [Tomtec]), indexation for weight, height, BSA, BMI and TBV according to Lindemann et al. Evaluation of the index quality using standard deviations and coefficients of correlation. **Results:** LV volumes in comparison to different indexes, SD and correlations in descending order: Group I: BSA (SD 22.0-24.2%, r = 0.86-0.89), weight (SD 20.2-22.5%, r = 0.85-0.87), TBV (SD 20.5-22.7%, r = 0.86-0.88), height (SD

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27.9-29.8%, r = 0.84-0.87), BMI (SD 42.2-46.1%, r=-0.12 - -0.2). Group II: BSA (SD 14.8-17.9%, r = 0.82-0.85), TBV (SD 14.5-17.5%, r =0.81-0.84), weight (SD 17.1-19.6%, r = 0.79-0.83), height (SD 20.6-23.4%, r = 0.79-0.83), BMI (SD 23.1-25.8%, r = 0.54-0.57). Group III: BSA (SD 17.9-21%, r =0.76-0.78), TBV (SD 20.6-21.8%, r =0.76-0.78), weight (SD 21.8-23%, r =0.75-0.77), height (SD 22.1-26.6%, r =0.74-0.76), BMI (SD 23.7-28.3%, r =0.55-0.57). **Conclusion:** There are differences between index variables and LV volumes as well as different age groups of healthy individuals. BV correlates well ranking behind BSA, which should be used as index to account for cardiac growth when creating pediatric reference values.

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Real World Use of Three-Dimensional Left Ventricular Ejection Fraction

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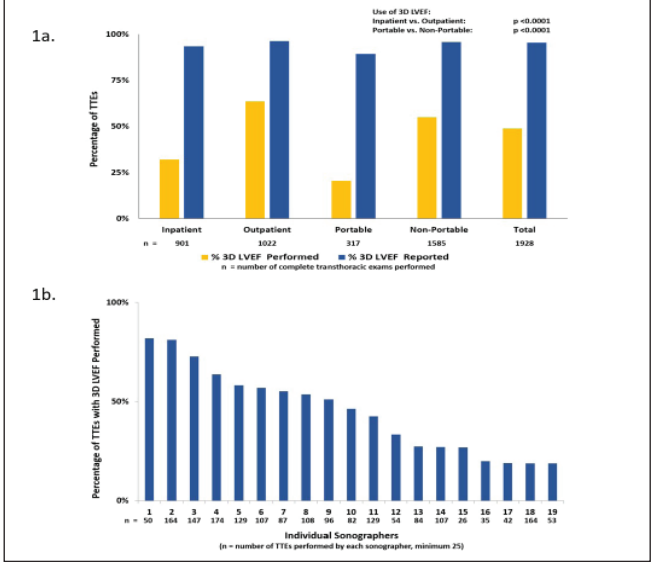
Background: Three-dimensional left ventricular ejection fraction (3D LVEF) is recommended by the American Society of Echocardiography as the most accurate and reproducible measurement of left ventricular function. 3D LVEF on transthoracic echocardiogram (TTE) may be underused with variable performance based on patient and exam characteristics. We examined the use of and variability in 3D LVEF acquisition in an academic medical center echocardiography laboratory. **Methods:** We retrospectively analyzed all complete resting TTE studies between 8/1/2017 to 10/31/2017 (excluding exams with microbubble contrast echocardiograms). Patient demographics, exam location, exam indication, performing sonographer, and LVEF results were obtained. Exams with and without 3D LVEF acquisition were compared. **Results:** 3D LVEF was performed in 943 (49%) of the 1928 complete TTEs included in the analysis; Bi-plane LVEF was performed in 46% of exams without 3D LVEF acquisition (1% of remaining exams had visual LVEF, 4% had no LVEF performed). Patients with 3D LVEF performed had a significantly lower average body mass index (BMI, kg/m^2) (27.4 ± 6.1 vs 28.3 ± 7.3, p = 0.002) and lower average age (years) (56.6 ± 18.2 vs. 62.9 ± 18.5). 3D LVEF use significantly varied based on exam/patient location (inpatient vs. outpatient and portable vs. non-portable, p<0.001) (Figure 1A). 3D LVEF use significantly varied based on performing sonographer (Figure 1B). Patients with an indication of cancer/chemotherapy (a population requiring serial/objective LVEF assessment) had significantly higher use of 3D LVEF (n=187/206 exams, 91%). 3D LVEF was reported to ordering provider 95% of the time it was performed and did not significantly vary across exam locations (Figure 1A). **Conclusion:** Use of 3D LVEF acquisition varied significantly based on patient characteristics (including BMI and age), patient location, and performing sonographer. However, when performed, 3D LVEF is almost always reported to provider. An increased use of 3D LVEF acquisitions in cancer/chemotherapy patients may represent an ideal real-world feasibility threshold for 3D LVEF use. Based on these results, initiatives to decrease sonographer variability and increase 3D LVEF acquisitions on inpatient/portable exams may lead to more consistent 3D LVEF assessment.

Figure 1. Significant differences are seen in the use of 3D LVEF by transthoracic echocardiogram and patient location (1a) and by performing sonographer (1b).



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Automated 3-Dimensional Single Beat Real-Time Volume Color-Flow Doppler Echocardiography: A Validation Study of Right and Left Heart Flows

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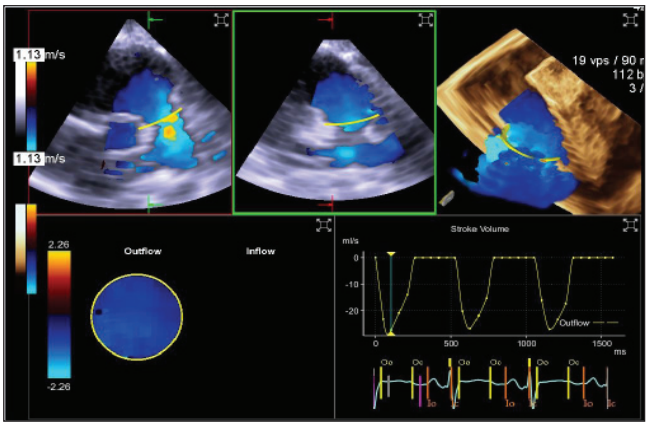
Background: Novel quantification of stroke volume by mitral inflow and aortic outflow using automated real-time three-dimensional volume color-flow Doppler echocardiography (3D-RT-VCFDE) is more accurate than two-dimensional echocardiography and has excellent correlation with cardiac magnetic resonance imaging-based flows in adults. This technology is applied for the first time to the right heart and in children. **Methods:** 3D-RT-VCFDE was performed in 34 children who provided 61 image sets of flow through the aortic (AV), mitral (MV), pulmonary (PV) and tricuspid (TV) valves. Right heart flows were compared with left heart flows. Flows were compared with stroke volumes of the right (RV) and left (LV) ventricles and Qp/Qs determined by the Fick method in 31 children with atrial shunts. **Results:** The mean age was 8.0 ± 3.3 years, and the mean weight was 27.8 ± 10.0 kg. The mean temporal resolution for flow analyses was ≥ 22 volumes/second. In conditions with no shunt, the correlations were: AV with MV flows (r=0.98), PV with TV flows (r=0.96), RV stroke volume with PV flow (r=0.95) and with TV flow (r=0.93), LV stroke volume with AV flow (r=0.87) and with MV flow (r=0.89). Fick Qp/Qs correlations were: PV/AV ratio (r=0.84), TV/MV ratio (r=0.87) and RV/ LV ratio (r=0.70). **Conclusions:** Stroke volume determined by automated RT-3D-VCFDE is feasible in children and in the right side of the heart. This technique potentially provides a non-invasive alternative to historically invasively acquired hemodynamic data and to cardiac magnetic resonance imaging.



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Three Dimensional Real Time Strain Echocardiography in Children Following Chemotherapy: A Novel Diagnostic Tool

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Background: Although, anthracyclines are efficacious in pediatric cancers, their utility is limited by progressive cardiotoxicity. Recent studies show impairment of left ventricle (LV) strain using 2D speckle tracking echocardiography. However, changes in various planes of myocardial motion, torsion and twist have not been studied. We hypothesized that the newer 3D real-time strain echocardiography (3DSE) imaging would detect subclinical functional abnormalities in children following anthracycline chemotherapy. **Objective:** To compare LV strain, torsion and twist on 3DSE in asymptomatic children with normal shortening fractions following completion of anthracycline chemotherapy vs. normal controls. **Method:** This was a retrospective echocardiogram review of patients who had received anthracycline chemotherapy for pediatric cancers >1 year earlier. Patients who had undergone bone marrow transplant were excluded. Patients with chest pain, murmur or syncope and normal echocardiograms acted as controls. Echocardiograms (Philips IE33) were read by a single reader blinded to clinical data. Full volume data consists of 4 adjacent sub-volumes over four consecutive beats acquired during a breath-hold to minimize the artifacts and analyzed offline (Tomtec Inc software). During the 3D analysis, 5 planes are displayed and endocardium was traced using a semi automatic method with manual adjustments. Global longitudinal and circumferential (GLS and GCS) and segmental 3D strain, LV twist, LV torsion, LV ejection fraction, and 3D systolic dyssynchrony index (SDI) were generated. Statistical analysis included student t-test and Chi-square test to compare groups. **Results:** Our cohort (n=113) included 31 (27%) subjects who had received anthracyclines. The groups were similar in age at echocardiogram and gender distribution. The 3D GLS%, GCS% 3- planes, and SDI were significantly abnormal in the anthracycline group but LV torsion and

twist were comparable to controls. (Table) **Conclusions:** Even years after anthracycline chemotherapy, asymptomatic pediatric subjects with normal LV volume have significant abnormalities in ejection fraction, 3D global strains and SDI but normal LV torsion and twist. Further longitudinal studies of 3DSE are required to assess progression of these abnormalities, if any.

Comparison of demographic and echo parameters between chemotherapy and normal group			
Echo parameters (mean ± SD) (n%)	Chemotherapy (n=31)	Normal Controls (n= 82)	P value
Age	13.1±3.3	12.1±3.9	0.2
Gender (male)	50 (61%)	21 (68%)	0.33
Ht (cm)	154.5 ± 21.1	151.6 ± 21.5	0.5
Wt (kg)	55.6 ± 24.5	48.6 ± 20.4	0.13
End-diastolic volume (EDV)	89.2 ± 39.2	78.0 ± 28.0	0.09
End-systolic volume (ESV)	38.5 ± 20.9	27.6 ± 11.9	**0.001***
Stroke Volume (SV)	50.6 ± 21.7	50.4 ± 17.4	0.95
Ejection Fraction (EF)	57.9 ± 7.3	64.9 ± 5.4	**0.000***
3D GLS (%)	-18.2 ± 3.0	-22.8 ± 3.1	**0.000***
3D GCS (%)	-26.6 ± 5.0	-31.2 ± 4.5	**0.000***
Twist (degree)	11.2 ± 5.0	9.7 ± 4.3	0.13
Torsion (degree/cm)	1.5 ± 0.8	1.3 ± 0.6	0.16
SDI (%)	4.4 ± 1.7	3.7 ± 1.2	**0.02***
3D Strain Global Avg. Peak min (%)	-30.5 ± 5.2	-35.9 ± 4.5	**0.000***
Long-Strain Global Avg. Peak (%)	-17.9 ± 3.0	-22.2 ± 3.2	**0.000***
Circum-Strain Global Avg. Peak (%)	-26.1 ± 5.0	-30.5 ± 4.6	**0.000***
Radial-Strain Global Avg. Peak (%)	36.9 ± 6.0	44.3 ± 5.5	**0.000***

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Right Ventricular Function Assessed by Novel Three Dimensional Tricuspid Annular Plane Systolic Excursion Method Improves After Transcatheter Aortic Valve Replacement

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Background: Right ventricular (RV) function is an important consideration when assessing candidacy for both surgical and transcatheter aortic valve replacement (TAVR). There have been conflicting reports regarding changes in RV function and hemodynamic improvement after TAVR. The purpose of our study was to examine acute changes after TAVR using three-dimensional transesophageal echocardiography (3DTEE) with novel RV analysis software. **Methods:** 3DTEE was performed on 20 patients who underwent TAVR under general anesthesia. RV 3DTEE images were acquired before and after aortic valve replacement. Images were acquired using Siemens SC2000 ultrasound systems and analyzed using prototype Siemens UnifiedHeart software (Siemens Healthineers, Mountain View, CA) to track the tricuspid valve annulus and RV endocardial borders throughout the cardiac cycle with automated identification and manual adjustments. We obtained RV EF, lateral tricuspid annular plane systolic excursion (TAPSE) and 3D TAPSE. Lateral TAPSE was obtained from a single point and 3D TAPSE from the maximum excursion of all tricuspid annular points. **Results:** 3D RV analysis was successfully performed on all patients. 3D TAPSE was the only parameter measured that significantly increased immediately after aortic valve deployment (PreTAVR: 8.1±3.3 mm; PostTAVR: 10.7±4.5 mm; p=0.003). The following trends did not reach statistical significance. Lateral TAPSE increased after TAVR (PreTAVR: 6.9±3.4 mm; PostTAVR: 8.04±3.7 mm; p=0.07). RV EF increased slightly after TAVR (PreTAVR: 41±12%; PostTAVR: 43±13%; p=0.47). RV end-diastolic volume decreased after TAVR (PreTAVR: 71±30 ml; PostTAVR: 68±29 ml; p=0.32). RV end-systolic volume decreased after TAVR (PreTAVR: 43±22 ml; PostTAVR: 39±21 ml; p=0.40). RV stroke volume increased after TAVR (PreTAVR: 28±12 ml; PostTAVR: 29±14 ml; p=0.76). **Conclusion:** RV function was evaluated by 3D TEE before and immediately after TAVR. Using novel RV analysis software, 3D RV volumes and EF did not change acutely. While lateral TAPSE values did not show a significant increase, 3D TAPSE may be a more sensitive indicator of RV function.

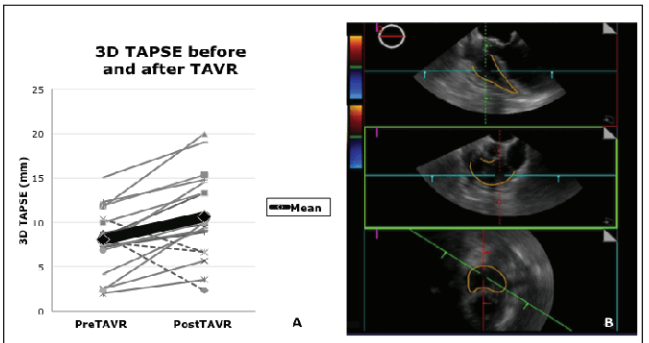

Figure 1. (A) Individual and mean changes in 3D TAPSE after TAVR. (B) Example of 3D RV contour after TAVR.

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Will TAVI Change the Instant Geometry of Mitral Valve? A Sight from Three-Dimensional Transesophageal Echocardiography

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Objective: Transcatheter aortic valve implantation (TAVI) is a thriving procedure for severe aortic valve stenosis. The instant geometry of mitral valve after TAVI procedure is not fully studied. In this study, we reconstruct the instant geometry of mitral valve and its coupling relationship with aortic valve of by three-dimensional transesophageal echocardiography (3D-TEE) in order to investigate the instant structural changes of mitral valve after TAVI. **Methods:** Twenty patients who underwent TAVI for severe aortic valve stenosis were enrolled. 3D-TEE was performed before TAVI and after TAVI immediately. The instant geometry of mitral valve and the coupling relationship of mitral valve and aortic valve were reconstructed by semi-automatic analysis software based on the dataset of 3D-TEE. The length of anterior and posterior leaflet of mitral valve, the non-planar angle of mitral valve annulus, the length of anterior to posterior mitral valve annulus, the length of anterior-lateral to posterior-medial length of mitral valve annulus, and the angle between aortic valve annulus and anterior-posterior mitral valve annulus were acquired and compared before and after TAVI. **Results:** The structure of mitral valve and its position with aortic valve before TAVI and immediate after TAVI were successful reconstructed. There were no significant changes in the length of anterior leaflet or posterior leaflet of mitral valve before and after TAVI. The non-planar angle of mitral valve annulus was not changed (150.30°±16.02° *vs.* 151.74°±13.90°, $p>0.05$). The anterior to posterior length of mitral valve annulus showed no changes (2.99±0.27cm *vs.* 2.91±0.19cm, $p>0.05$) while the anterior lateral to posterior medial length of mitral valve annulus was shortened after TAVI (3.27±0.10cm *vs.* 2.98±0.20cm, $p<0.05$). The angle between aortic valve annulus and anterior-posterior mitral valve annulus was not changed after TAVI (117.92°±6.33° *vs.* 117.86°±6.49°, $p>0.05$). **Conclusions:** TAVI does not change the instant geometry of mitral valve and does not change the coupling relationship of mitral valve and aortic valve. By means of 3D-TEE, the geometry of mitral valve after TAVI can be evaluated accurately and rapidly. However, further studies are required for the changes of mitral valve's geometry and function after TAVI in a long period of follow-up.

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Best Three-dimensional Transesophageal Echocardiographic Methods for Assessment of Left Ventricular Volumes and Ejection Fraction

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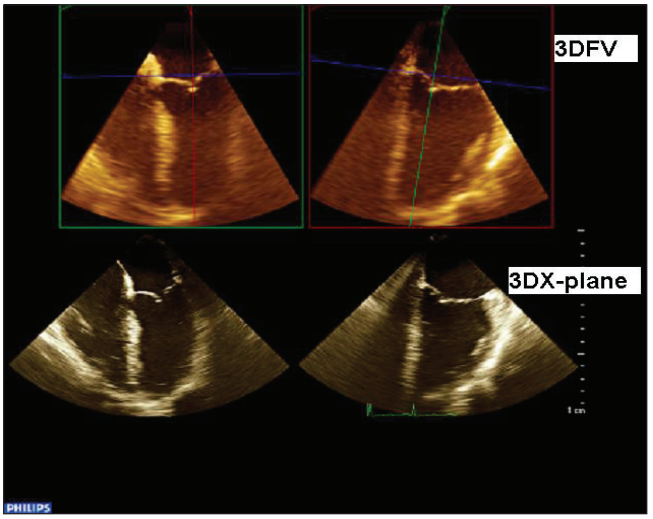
Background: 3D transthoracic echocardiography (3DTTE) has been validated to have good agreement with cardiac magnetic resonance for assessment of left ventricular ejection fraction (EF) with good interobserver reproducibility. Despite widespread use of 3D transesophageal echocardiography (3DTEE), 3DTEE methods of assessing of LV volumes and EF have not been validated against 3DTTE. **Objective:** Due to the difficulty associated with tracking endocardial borders from the full-volume (FV) 3DTEE dataset, various biplane methods (2DTEE, 3DX-plane, 3DFV) were compared to 3DTTE which served as a reference. **Methods:** A total of 60 consecutive patients (mean age 72 yrs, 40% female) were studied prospectively in a single large volume tertiary center. 3DTTE was performed just prior to 3DTEE. LV end-diastolic (EDV), end-systolic (ESV), stroke (SV) volumes and EF were calculated with Qlab 9, and 3DQ software, with semi-automated endocardial contours for 3DTTE and 3DFV. The corresponding parameters for 2DTEE and 3DX-plane methods were assessed using AGFA with manual endocardial contours. Mean differences were compared with paired two-tail T-test and limits of agreement

were determined with the Bland-Altman analysis. Measures were repeated on all 3DTEE studies by a second observer and the Intra-class Correlation Coefficient (ICC) method was used to assess interobserver reproducibility. **Results:** EF by all TEE modalities, showed good agreement with 3DTTE. EFs were 50.5±12.3, 53.1±12.2, 52.8±13.3, and bias±SD was 1.1±6.8, -1±8.5, -1.4±9.2 for 3DFV, 3DX-plane and 2DTEE respectively, as compared to 3DTTE (51.7±12). LV volumes by 3DFV were higher compared to 3DTTE (mean differences -13.2±26, -9.3±20.7, -3.6±12.5 and P values <0.001, 0.001, 0.027 for EDV, ESV, SV respectively). EDV and ESV by 2DTEE and 3DX-plane TEE were not statistically different from 3DTTE, but SV was higher (mean differences for SV -4.9±17, -5±19 and p values 0.031, 0.045 for 3DX- plane and 2DTEE respectively). There was excellent interobserver reproducibility with 3DFV (ICC = 0.94, 0.96, 0.98, 0.89 for EF, EDV, ESV and SV respectively) **Conclusion:** 2DTEE, 3DX-plane and 3DFV all show strong agreement with 3DTTE for EF assessment but can overestimate SV. Future studies should compare 3DV, 3DX-plane, and 2DTEE with CMR to measure the accuracy of TEE methods.



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Maximal Mitral Annular Area is Variable Between Different Cycle Lengths in Atrial Fibrillation

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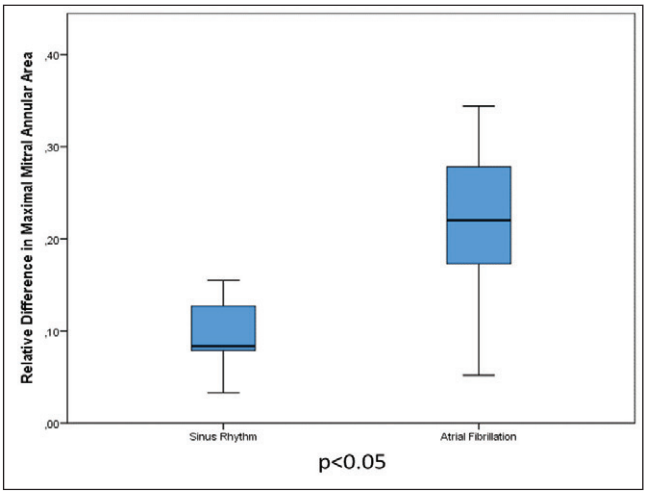
Background: With the evolution of transcatheter mitral therapies assessment of mitral annular (MA) dimensions and geometry is becoming important. Advances in 3-dimensional transesophageal echocardiography (3D-TEE) have enabled accurate estimation of MA size and dynamics in various disease states. Despite the frequent association between mitral valve disease and atrial fibrillation (Afib), little if any data exist regarding the dynamic MA dimensions in patients with Afib. Accordingly, we sought to determine maximal MA area size and variability in different cycles in patients with Afib and compare these findings with those of control subjects in sinus rhythm. **Methods:** Data obtained from 72 patients undergoing clinically indicated 3D transesophageal echocardiographic examination for evaluation of mitral valve disease at Mayo Clinic (Rochester, MN). Patients with paced rhythms, prosthetic heart valves and insufficient ECG tracings/poor image quality were excluded. Full volume 6 beat loops were analyzed offline for assessment of mitral annular area size with TomTec 4D MV Assessment 2.0 software (TomTec Imaging Systems GmbH, Munich, Germany). **Results:** Data from 14 patients with AFib and 14 patients with sinus rhythm were obtained. For each patient 6 different cycles were analyzed (168 cycles total: 84 Afib, 84 sinus). In atrial fibrillation median absolute difference in maximal MA area is 3.44 cm^2 (min 0.69 cm^2, max 5.21 cm^2), median relative difference in maximal MA area is 0.22 (min 0.05 max 0.34). In sinus rhythm median absolute difference in maximal MA area is 1.04 cm^2 (min 0.420 cm^2, max 2.08 cm^2), median relative difference in maximal MA area is 0.083 (min 0.03, max 0.16) (Figure 1). Cycle to cycle median absolute difference in maximal MA area and median relative difference in maximal MA area are greater in Afib patients ($p<0.05$ for both measurements).There is statistically significant positive correlation between relative cycle length and relative maximum MA area in Afib ($r=0.323$, $p=0.004$). No correlation exists between sinus cycle length and MA area ($p=0.084$). **Conclusion:** Our data suggests that maximal mitral annular area shows significant intraindividual cycle to cycle variability in atrial fibrillation. There is positive correlation between cycle length and mitral annular area.



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A Preliminary Methodology Study of Producing 3D Printing Left Heart Model by Multimodal Medical Image Fusion Technology

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Background: 3D printing heart always chose the CTA as data source, but can not accurately reflec the heart valve anatomy. This study aimed to fuse the ultrasonic valve images and CT images, obtain 3D printing heart with abundant anatomical information and new methods of image processing. **Methods:** We retrospectively analyzed 13 patients with atrial fibrillation and no structural cardiac diseases under cardiac examinations of 3D-TEE and CTA to obtain DICOM images and processed the data afterward by using software Mmimcs. Then, we built model for Group A through the cardiac CTA data obtained, and for Group B, we leveraged software 3-Matic to align and joint the ultrasonic images of valves to the right position of the cardiac CT model. By direct observation, we made comparison between the two groups for the data of shapes and the structures of the valves that from CT and ultrasonic, and measured the parameters related to valve ring, including area (A), circumference (C), maximum diameter (Dmax) and minimum diameter (Dmin). We also placed the two images overlapped, then measured the angles between the plane of the two valve rings and worked out the absolute difference of the values measured, performing the correlated analysis. **Results:** All the 13 patients completed the whole experiment. By direct observation on valves, we noticed that valve shape from ultrasonic was more clear and complete than that from the CT, the parameters of valves between that from CT and that from ultrasonic made no statistic difference ($P> 0.05$) and were at high consistency. The mean values and standard deviation of aortomitral angles in both were 3.15°±0.88°,and 2.87°±0.76° respectively. 3D models of two patients were printed and measured, showing the difference of each parameter between the measured value and the digital model was at 0.1-0.3mm. **Conclusion:** The comprehensive data analysis, ultrasonic heart valve with CT image fusion is feasible. Ultrasonic valve anatomy shows better, disc ring size and stitching location accurate, contribute to improve the 3D printing heart model biofidelity.

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Comparison of Left Ventricular Function and Volume in Transthoracic and Transesophageal 3-Dimensional Echocardiography

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Background: Assessment of left ventricular (LV) ejection fraction (EF) and volumes by three-dimensional echocardiography (3DE) is more accurate than 2D echocardiography, however the comparison of transthoracic (TTE) and transesophageal (TEE) is unknown. We hypothesized that EF and LV volumes would be similar but have a better correlation at higher volume rates. **Methods:** This prospective study compared LVEF and volumes using real time 3DE by TTE and TEE on consecutive patients when possible in a total of 41 patients. 3D TEE images were acquired using a Siemens SC2000 immediately followed by 3D TTE image acquisition. The LVEF and volumes were then calculated using the Siemens automated multi-beat volume LV analysis (eSie LVA™) with measurements of beat to beat EF, stroke volume (SV) and LV volumes. Adjustments could be made to identify endocardial contours for end systole and end diastole. The patients were divided into a high-volume rate cohort (HVC) of 19 patients defined as a volume rate > 15 volume per second (VPS) and a low-volume cohort (LVC) of 22 patients who had volume rates < 15 VPS. **Results:** A total of 41 patients (25 males, 16 females) with an average age of

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62 ± 17.6 years and average BMI of 27.6 ± 6.4). The patients in the HVC had an average volume rate 23.8 VPS and 17.7 VPS, TTE and TEE, respectively and in the LVC 11.8 VPS and 14.6 VPS, respectively. The average EF for TTE and TEE were 60.0 ± 7.8% and 59.2 ± 7.3%, respectively. The correlation of 3D LVEF, end diastolic volume (EDV), end systolic volume (ESV) and stroke volume (SV) between TTE and TEE for the HVC were excellent (r =0.96, 0.85, 0.93, and 0.85); and for the LVC were good (r = 0.7, 0.91, 0.82, and 0.89, respectively). Regardless of volume rate, 3D TTE resulted in larger SV, EDV, and ESV compared to 3D TEE, with a mean difference of 10.9 cc and 10.8 cc for SV, 17.4 cc and 9.3 cc for EDV, 6.6 cc and 2.2cc for ESV. The mean difference of LVEF between the HVC and LVC for TTE and TEE were 0.27% and 1.3%. **Conclusion:** This is the first study to compare LV volumes and LVEF between 3D TTE and 3D TEE. Assuredly, LVEF derived by either 3D TTE or TEE have excellent correlation, however, there is underestimation of LV volumes.

P1-172

Multiview 3D Fusion Echocardiography Using a Novel Transducer and Respiratory Tracking Technique: First Results in Humans

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Background: 3-dimensional echocardiography (3DE) has been one of the greatest innovations in cardiac imaging to date, but limitations inherent to ultrasound physics have been a barrier to ongoing technological advancements. While developments in ultrasound transducer technology and post-processing techniques have undoubtedly bettered 3DE, but they have failed to address inherent weaknesses of 3DE. These include a limited volume-of-view (VOV) and suboptimal endocardial definition resulting from non-perpendicular angles of ultrasound incidence relative to important structures like the left ventricle. Multi-view 3-dimensional fusion echocardiography (M3DFE) offers a solution to this dilemma by fusing 3DE datasets from complementary acoustic windows. **Methods:** Real-time M3DFE datasets were acquired from eleven volunteers during a breath-hold maneuver with i) an unmoving transducer capturing a standard apical view, ii) slight movement of the transducer to include non-standard apical views, and iii) the probe positioned at both parasternal and apical windows. Infrared cameras were used to track the 3-dimensional position and orientation of the transducer and chest markers. A range of two to five datasets were recorded per breath-hold for each of these three groups. Multi-planar reconstruction of both M3DFE and standard apical 3DE datasets was performed to generate four- and two- chamber 2-dimensional planes which were then analyzed and compared. Subjective assessments included i) successful alignment of datasets and ii) endocardial border definition (rated on a three-point scale from 0 to 2). Objective assessments included i) contrast, ii) contrast-to-noise ratio (CNR), iii) signal-to-noise ratio (SNR) and iv) % increase in VOV. Endocardial border definition, contrast, CNR and SNR were assessed for each of the standard six segments for both the apical two- and four-chamber planes. **Results:** At least one successfully aligned M3DFE dataset was generated for each of the three transducer position categories for all eleven volunteers. Table 1 summarizes the results.

Table 1: Qualitative and Quantitative Parameters Assessing Image Quality and Volume of View

	Contrast	CNR	SNR	Endocardial Border Definition	ΔVOV (%)
	mean +/- SD	mean +/- SD	mean +/- SD	mean +/- SD	mean +/- SD
Unmoving Transducer - Standard Apical 3DE	55 +/- 14	3.8 +/- 0.7	7.2 +/- 1.6	0.96 +/- 0.27	
Unmoving Transducer - M3DFE	79 +/- 17	7.7 +/- 2.4	10.6 +/-2.2	1.30 +/- 0.35	N/A
Unmoving Transducer - Result of Paired T-test	p < 0.001	p < 0.001	p < 0.001	p < 0.001	
Moving Transducer (Non-standard Apicals) - Standard Apical 3DE	58 +/- 12	4.7 +/- 1.7	7.9 +/- 2.0	1.00 +/- 0.21	
Moving Transducer (Non-standard Apicals) - M3DFE	80 +/- 16	7.9 +/- 1.6	10.6 +/- 3.2	1.29 +/- 0.32	33 +/- 25
Moving Transducer (Non-standard Apicals) - Result of Paired T-test	p < 0.001	p < 0.001	p < 0.01	p < 0.001	
Moving Transducer (Apical(s) + Parasternal) - Standard Apical 3DE	60 +/- 18	4.1 +/- 1.4	6.3 +/- 1.2	1.10 +/- 0.17	
Moving Transducer (Apical(s) + Parasternal) - M3DFE	89 +/- 9	10.3 +/- 2.1	11.8 +/- 4.1	1.45 +/- 0.32	47 +/- 12
Moving Transducer (Apical(s) + Parasternal) - Result of Paired T-test	p < 0.001	p < 0.001	p < 0.001	p < 0.01	

Conclusion: This novel M3DFE technique results in successful fusion of 3DE datasets. Compared to standard 3DE datasets, M3DFE datasets demonstrate enhanced VOV and improvements in both subjective and objective measures of image quality.

P1-173

2D vs. Novel 3D Assessment of Impella Temporary Mechanical Circulatory Support Devices

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Background: Impella devices provide temporary mechanical circulatory support (MCS) by means of a catheter consisting of a left ventricular (LV) inlet, a microaxial pump within the catheter, and an outflow port in the proximal aorta. The recommended position of the inlet is 4-4.5cm below the aortic valve annulus. Following initial placement, the device is prone to migration, potentially leading to ineffective support, hemolysis, ventricular arrhythmia, or mitral regurgitation. Positioning is typically monitored by echocardiography. However, the Impella device has a bend between the inflow and outflow ports, and traditional 2D-imaging may not be reliable in assessing the location of the device, as single plane 2D windows may not include both the inflow port and the aortic annulus, leading to foreshortening of the cannula and under-measurement of the distance. We hypothesized that 3D echocardiography provides more accurate characterization of the location of the Impella cannula. **Methods:** We analyzed 25 echocardiograms of patients supported with Impella devices, including the 5.0 and CP device types, which had analyzable 2D and 3D images. Measurements of the distance from the aortic annulus to the inflow port were made according to recommendations from 2D PLAX images. Three sets of measurements were made at end systole and at end diastole. Full volume 3D datasets acquired from the parasternal window were acquired an analyzed using Qlab (Philips, Andover, MD) software to overcome possible foreshortening of the Impella cannula. In addition, the 3D dataset was used to measure the angle deviation of the cannula from the long axis of the left ventricular outflow tract. **Results:** There was no significant difference between 2D and 3D measurements of the aortic annulus to inflow port distance (3.30cm vs. 3.33cm, p=0.45). The average measurement discrepancy between 2D and 3D techniques was 0.23cm in systole and 0.24cm in diastole. 14/25 (56%) of studies had at least one measurement in the range of 3-4.5 cm, with no difference between 2D and 3D techniques (3.78cm vs. 3.81cm, p=0.44). Differences between 2D and 3D measurements did not correlate with the angle of the device (R=0.09). **Conclusion:** There was no recognizable benefit of 3D techniques in measuring aortic annulus to Impella inflow port distance, though a larger sample size may be necessary to detect a significant difference. 3D imaging may have a benefit in observing other relationships, such as the mitral apparatus, and bears ongoing investigation.

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Which Left Ventricular Outflow Tract Diameter (LVOTd) is Best for Assessment of Aortic Valve Area (AVA) in Bicuspid Aortic Valves (BAV) by the Continuity Equation (CE) - a 3D Transthoracic Echocardiographic Study?

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Background: Assessment of AVA is critical in determining aortic stenosis severity to guide appropriate intervention. Doppler-derived CE is the cornerstone for calculation of AVA (AVA = $0.785x(LVOTd)^2xLVOT_{VTI}/AV_{VTI}$). LVOTd remains the Achilles heel of this method with frequent underestimation by 2D imaging and lack of consensus regarding anatomic level of measurement (0.5-1cm "apical" in the LVOT ($LVOTd_{Api}$) vs annulus level ($LVOTd_{Ann}$)). Accurate estimation of AVA in BAVs is more challenging due to the elliptical orifice and eccentric flow pattern. We aimed to define the optimal LVOTd ($LVOTd_{Api}$ vs $LVOTd_{Ann}$ by 2D vs 3D) for calculation of the AVA in comparison to the reference standard of AVA by 3D planimetry (AVA_{3D}) in BAVs. **Methods:** A retrospective review of all transthoracic echocardiograms (TTE) with a BAV assessed by 3D imaging was conducted. 2D-$LVOTd_{Api}$ and 2D-$LVOTd_{Ann}$ were measured from the parasternal window. 3D-LVOTd values were derived from 3D measurements of circumference, area and average of major-minor dimensions at the "apical" (3D-$LVOTd_{Api\text{-}Circ}$; 3D-$LVOTd_{Api\text{-}Area}$; 3D-$LVOTd_{Api\text{-}Ave}$) and annulus (3D-$LVOTd_{Ann\text{-}Circ}$; 3D-$LVOTd_{Ann\text{-}Area}$; 3D-$LVOTd_{Ann\text{-}Ave}$) levels. Standard $LVOT_{VTI}$ and AV_{VTI} Doppler parameters were recorded for calculation of AVA by the CE. 3D planimetry of the BAV orifices (AVA_{3D}) was performed. **Results:** 52 TTEs were included (39±15years; 42% females). Mean AVA_{3D} was 3.55±1.92cm^2. Estimated AVAs by CE using 2D-$LVOTd_{Api}$, 2D-$LVOTd_{Ann}$, 3D-$LVOTd_{Api\text{-}Circ}$, 3D-$LVOTd_{Api\text{-}Area}$, 3D-$LVOTd_{Api\text{-}Ave}$, 3D-$LVOTd_{Ann\text{-}Circ}$, 3D-$LVOTd_{Ann\text{-}Area}$, and 3D-$LVOTd_{Ann\text{-}Ave}$ were 2.62±1.46cm^2, 3.03±1.74cm^2, 3.43±1.96cm^2, 3.22±1.84cm^2, 3.23±1.88cm^2, 3.41±1.92cm^2, 3.23±1.84cm^2, and 3.28±1.88cm^2. AVA by CE that correlated best with AVA_{3D} were obtained using 3D-$LVOTd_{Api\text{-}Circ}$ (Intraclass correlation (ICC) 0.989) and 3D-$LVOTd_{Ann\text{-}Circ}$ (ICC 0.988). Both 2D-LVOTds systematically underestimated the AVA but 2D-$LVOTd_{Ann}$ was better than 2D-$LVOT_{Api}$ (ICC 0.873 vs 0.695). **Conclusions:** LVOTd derived from 3D circumference measurements (either 3D-$LVOTd_{Api\text{-}Circ}$ or 3D-$LVOTd_{Ann\text{-}Circ}$) resulted in more accurate estimation of the AVA. 2D-$LVOTd_{Ann}$ provided a better assessment of the AVA than 2D-$LVOT_{Api}$ and should be the preferred 2D standard for BAVs.

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Different Change of Mitral Valve Geometry after MitraClip Therapy between Patients with Atrial Mitral Regurgitation and Functional Mitral Regurgitation: Three-Dimensional Transesophageal Echocardiography Study

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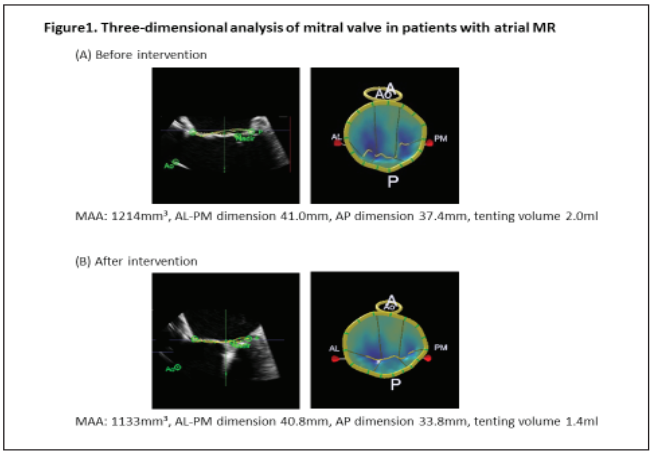
Background: The purpose of this study was to evaluate the impact of MitraClip procedure on mitral valve (MV) geometry in patients with atrial mitral regurgitation (MR) compared to those with functional MR using intraprocedural real-time three-dimensional transesophageal echocardiography (3D TEE). **Methods:** From a total of 400 patients who underwent MitraClip procedure, we selected 43 patients with normal mitral leaflet and chronic atrial fibrillation. We classified them into two groups: atrial MR, patients with left ventricular ejection fraction (LVEF) ≥50% (n=22), and functional MR, those with LVEF <50% (n=21). Mitral annular area (MAA), mitral annular anterior-posterior and anterolateral-posteromedial diameters, and tenting volume were evaluated using 3D TEE datasets. The change of MV parameters before and after procedure was also compared between 2 groups. Residual MR severity and MV mean pressure gradient after procedure and 1 month were assessed. MR severity was graded as follows; mild or less=1, moderate=2, moderate-severe=3, severe=4. **Results:** At baseline, atrial MR had larger MAA (1228 Vs. 1054, P<0.05) and smaller tenting volume (1.0 Vs. 3.1, P<0.05) compared to functional MR. The change of MAA and anterior-posterior diameter were larger in atrial MR compared with functional MR (ΔMAA: 93.6 vs. -9.4 mm2; Δanterior-posterior diameter: 3.6 vs. 0.1, both *P*<0.01), but there were no differences in the change of anterolateral-posteromedial diameter and tenting volume between 2 groups (Δanterolateral-posteromedial 0.1 vs 0.1 mm, P=0.78 ; Δtenting volume; 0.01 vs. 0.13, P=0.49). Residual MR after MitraClip was smaller in atrial MR compared to functional MR (1.1 vs 1.7, P<0.01). Degree of MR and MV mean pressure gradient at 1 month after procedure were not changed compared to those at a day after procedure in both groups. **Conclusion:** Atrial MR patients experienced significant reduction of anterior-posterior diameter resulting in good acute outcome. Both atrial MR and functional MR exhibited an immediate reduction in the severity of MR, which persisted for a month.



P1-176

Evaluation of Subclinical Cardiac Dysfunctions in Systemic Lupus Erythematosus with Three-Dimensional Speckle Tracking Echocardiography

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Objective: Systemic lupus erythematosus (SLE) can lead to cardiac dysfunctions and left ventricular hypertrophy(LVH). The purpose of the study was to investigate subclinical dysfunction and LV geometry changes in SLE patients using three-dimensional speckle-tracking echocardiography (3D-STE). We also interrogated the correlations between 3D-STE parameters and disease activity. **Method:** Forty patients with SLE (study group) and 40 sex- and age-matched healthy (control group) were recruited into the study. Disease activity was evaluated for all SLE patients by SLEDAI 2000 (SLEDAI-2K) score at the onset of checkup, and further divided into subgroups (group A, group B). Group A was comprised patients having SLEDAI scores<10 (inactive or mildly active), and Group B was comprised patients having SLEDAI scores ≥10(moderately active or severely active). LV global longitudinal strain (GLS), global circumferential strain (GCS), global radial strain (GRS), LV end-diastolic volume (LVESV), LV end-systolic volume (LVEDV) and LV mass (LVM) were measured by 3D-STE. **Results:** ①LV GLS, GCS and GRS were significantly reduced in SLE patients compared with controls(all P<0.001). LVMI, LVEDV and LVESV were increased in SLE patients (all P<0.001). In subgroups, GLS and GRS were significance decreased in group B than those of group A (all P<0.001). GLS and GRS had significance correlations with SLEDAI scores. SLEDAI scores was independently associated with LVH (OR=20.805, P<0.029). **Conclusions:** 3D-STE is a simple and non-invasive method to identify the LV subclinical dysfunction in SLE patients. The activity of SLE is independently associated with LV remodeling and systolic function.

P1-177 Moderated Poster

Functional Tricuspid Regurgitation: Impact of Right Ventricular Remodeling on Tricuspid Valve Tethering

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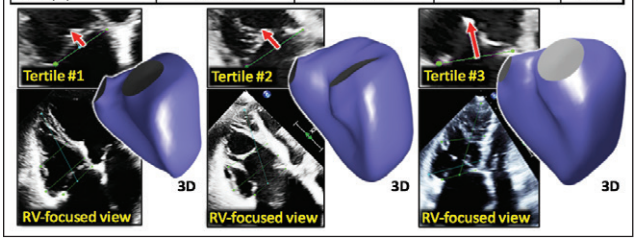
Background: Functional mitral regurgitation has been associated with left ventricular dilatation, papillary muscle displacement and leaflet tethering. It is assumed that in functional tricuspid regurgitation (FTR), similar remodeling occurs in the right ventricle (RV), resulting in tricuspid valve (TV) leaflet tethering. However, in severe FTR, the TV leaflets can be either tethered or non-tethered. Understanding the physiology of FTR is important, as attention has turned toward the development of devices that alleviate TR. We sought to identify the spectrum of RV remodeling in patients with severe FTR and its impact on TV tethering. **Methods:** We studied 74 patients (71±16 years) with severe FTR (vena contracta ≥0.7 cm), using 2D and 3D transthoracic echocardiography. Right atrial volume, tricuspid annulus (TA) diameter (4-chamber view), RV end-diastolic base (RVEDb), mid (RVEDm) and length (RVEDL) dimensions and RV free wall strain (RV focused view) were measured. RV volumes and ejection fraction (RVEF) were measured from 3D full-volume datasets. History of atrial fibrillation was recorded from the electronic medical record. Patients were divided into tertiles of tethering height (<0.78 cm, n=25; 0.78-1.1 cm, n=27; >1.1 cm, n=22). Intergroup comparisons were performed using ANOVA. Chi-squared test was used to test the differences in the prevalence of atrial fibrillation. **Results:** Age was inversely associated with worse tethering and there was a trend towards higher incidence of atrial fibrillation in the lowest tethering tertile, despite smaller right atrial volumes. Increased TV tethering was associated with adverse RV remodeling, including larger TV annulus, RV dimensions and volumes. RV free wall strain was worse in patients with greater tethering, while 3D RV EF showed no differences. **Conclusions:** These results suggest that there is a spectrum of patients with severe FTR. On one side are patients with increased TV tenting, TA dimensions, RA and RV cavity enlargement and on the other are those with less tenting, smaller TA dimensions and RA and RV cavity size. These morphological changes should be taken into account when choosing the type of device to improve TR in individual patients.

	TV tethering <0.78	TV tethering 0.78-1.1	TV tethering >1.1	p
Age (yrs)	77 ± 16	72 ± 17	64 ± 14	0.02
Afib (%)	52	44	23	0.11
VC (cm)	0.82 ± 0.09	0.91 ± 0.22	1.07 ± 0.39	0.005
RAVi (ml/m2)	50 ± 23	68 ± 34	83 ± 32	0.001
TV annulus (cm)	4.0 ± 0.6	4.5 ± 0.7	4.8 ± 0.6	<0.001
RV base (cm)	4.9 ± 0.6	5.7 ± 0.9	6.4 ± 0.8	<0.001
RV mid (cm)	3.7 ± 0.6	4.5 ± 1.0	5.3 ± 0.9	<0.001
RV length (cm)	7.7 ± 0.9	8.7 ± 1.3	8.8 ± 0.8	<0.001
RV free wall strain (%)	-17 ± 6	-12 ± 4	-13 ± 4	0.005
3d EDVi (ml)	142 ± 39	189 ± 65	220 ± 56	<0.001
3d ESVi (ml)	86 ± 31	121 ± 50	141 ± 39	<0.001
3d EF (%)	40 ± 12	37 ± 10	37 ± 7	0.459



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Prevalence of Respiratory Variation in Left Ventricular Outflow Tract Obstruction in Hypertrophic Cardiomyopathy

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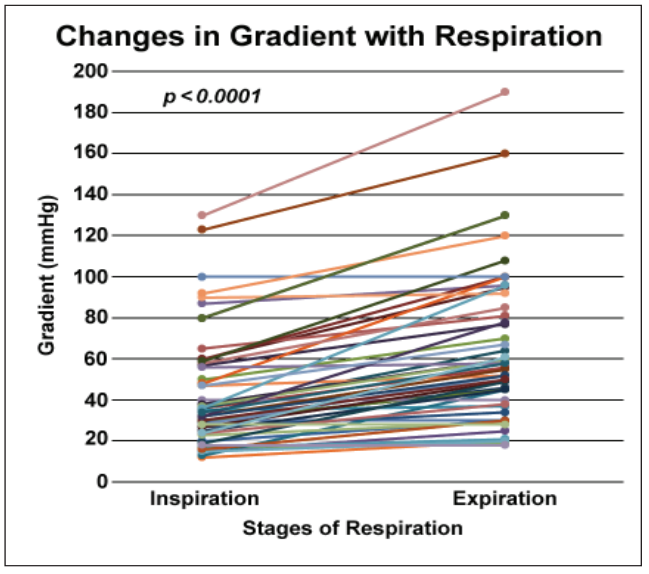
Background: Left ventricular outflow tract (LVOT) obstruction in patients with hypertrophic cardiomyopathy (HCM) is dynamic and sensitive to a number of physiologic variables. We have recently reported a counter-intuitive fluctuation in obstructive HCM, wherein LVOT gradients decreased during inspiration. Our observations challenged previous understanding of preload-dependent hemodynamics. We sought to assess the prevalence of this initial observation in a large HCM referral center. **Methods:** We evaluated patients referred to the HCM Outpatient Clinic at Aurora St. Luke's Medical Center, Milwaukee, WI. Comprehensive transthoracic echocardiogram was performed by dedicated sonographers immediately before cardiac consultation. Standard assessment of LVOT obstruction and measurement of resting gradients was performed. In patients with unprovoked resting LVOT obstruction, simultaneous recording with a respirometer was conducted to determine if respiratory variation in LVOT obstruction was present. Clinical variables were queried from the electronic health record. **Results:** From June 2011 to August 2017, we examined 463 patients with HCM. Of these, 216 (46.6%) patients had resting LVOT obstruction (patients were excluded if they demonstrated only provocable obstruction). Fifty-three of 216 patients (24.5%) had respiratory variation in LVOT obstruction, with peak gradients lowest during inspiration (43.3 mmHg ± 27.7) and highest during expiration (64.1 mmHg ± 37.0) (p-value <0.0001). Patients with respiratory variation in LVOT obstruction had a mean age of 57±18 years, mean body mass index (BMI) of 33.1 ± 6.5 kg/m^2, and 16 (30.2%) had a history of sleep-disordered breathing. **Conclusion:** Our study demonstrates a high prevalence of respirophasic variation in LVOT obstruction, occurring in 25% of HCM patients with resting LVOT obstruction. This finding is associated with increased BMI and sleep-disordered breathing. This phenomenon is preload-independent, likely related to reduced transmural pressure-dependent changes in afterload. It challenges conventional understanding of preload-dependent hemodynamics in HCM. Echocardiographers should be aware of this novel finding as it impacts the reporting of severity of obstruction in HCM.



P1-179

Utility of Doppler Flow Velocity Profiles in Prediction of Blalock-Taussig-Thomas Shunt Stenosis

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Background: Shunt stenosis is a challenging undertaking to evaluate by echocardiography. Ultrasound scatter and artifact from shunt material precludes accurate 2D assessment. We sought to assess the utility of serial changes in pulse pressure and pulsatility index of Doppler velocity profiles across a Blalock-Taussig Thomas (BTT) shunt in the evaluation and prediction of shunt stenosis. **Methods:** Fifty consecutive subjects with complex congenital heart disease and a BTT shunt as the sole source of pulmonary blood supply were studied (median age 4 (3-11) months). Three serial echocardiograms, ie. after 1 week and 1 month of the BTT shunt surgery and within 1 week of cardiac catheterization were used to evaluate Doppler flow velocities in the shunt. The pulse pressure (peak systolic -end diastolic), pulsatility index and resistance index were estimated using the modified Bernoulli equation and time averaged velocity of shunt flow. These data were compared with cardiac catheterization angiographic evaluation of the shunt and clinical oxygen saturation trends. **Results:** There was a positive correlation between (1) the serial Doppler estimates for pulsatility index and oxygen saturation. (r= 0.93, SEE = 3mmHg $P < 0.001$) and (2) the Doppler derived pulse pressure and distal angiographic measurements (r=0.9, SEE = 5mmHg; $P < 0.001$). Blande Altman analysis documented acceptable limits of agreement. In contrast, the caliber of the color jet and the peak systolic gradient had a poor correlation with angiographic measurements and the clinical status. **Conclusion:** The Doppler derived pulse pressure and pulsatility index can be used reliably to predict narrowing of the BT shunt with time when it is the sole source of pulmonary artery flow in the absence of elevated pulmonary vascular resistance. There was agreement between Doppler predicted pulmonary blood flow and catheter based calculations. These findings may prove a useful tool for interstage monitoring and peri-operative management.

P1-180

Sometimes Two Wrongs DO Make a Right: Opposite Effects of Errors in Left Ventricular Outflow Tract Area and Mean Velocity Estimation Largely Cancel Out When Calculating Stroke Volume

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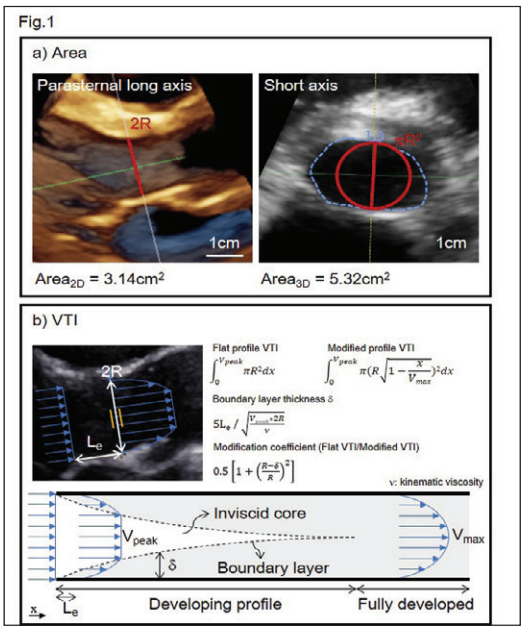
Background: Accurate computation of the effective orifice area (EOA) to evaluate aortic stenosis requires a robust computation of LVOT stroke volume for the continuity equation. The purpose of this study is to use 3D echocardiography and the LVOT fluid entrance length (from hydrodynamic theory) to accurately compute the $LVOT_{area}$ and effective velocity time integral ($LVOT_{VTI}$). **Methods:** Data were obtained in 22 healthy volunteers (age: 42.3±7, 10 males). 3D $LVOT_{area}$ was measured from the cross-sectional view where the LVOT diameter is typically measured (Fig.1a). The distance between the anterior cusp of the mitral valve hinge and LVOT measurement plane defined the entrance length (L_e) to estimate the boundary layer thickness δ, which grows with displacement along a pipe. The ratio between the velocity time integral of the flat and modified profile (boundary layer: parabolic, inviscid core: flat) was used to modify $LVOT_{VTLmod}$(Fig.1b). The EOA was calculated by dividing LVOT stroke volume ($LVOT_{area}$*$LVOT_{VTI}$) by the aortic valve velocity time integral. **Results:** $LVOT_{area}$ measured by 2D Doppler echocardiography was 14% smaller on average than 3D echocardiography (bias [limits of agreements]: -0.6 [0.7:-1.8]cm^2). In most (19/22) cases the usual 2D LVOT diameter was closely aligned to the short axis of the oval LVOT. The $LVOT_{VTI}$ was reduced by 18% after modification (3.4[4.8:2.0]cm). Due to these two compensatory factors, EOA calculated by the conventional method was similar after modification (P=0.2, 0.1[1.0:-07] cm^2)(fig.2). **Conclusion:** Our results support 3D echocardiography for accurate $LVOT_{area}$ measurement. We considered entrance effects to derive realistic velocity profiles and thus an accurate $LVOT_{VTI}$. In healthy volunteers, errors of $LVOT_{area}$ and $LVOT_{VTI}$ largely cancel out with each other when computing EOA, resulting in similar results to the conventional and corrected method. Whether this fortuitous cancellation remains in the setting of aortic stenosis and septal hypertrophy will require further studies.



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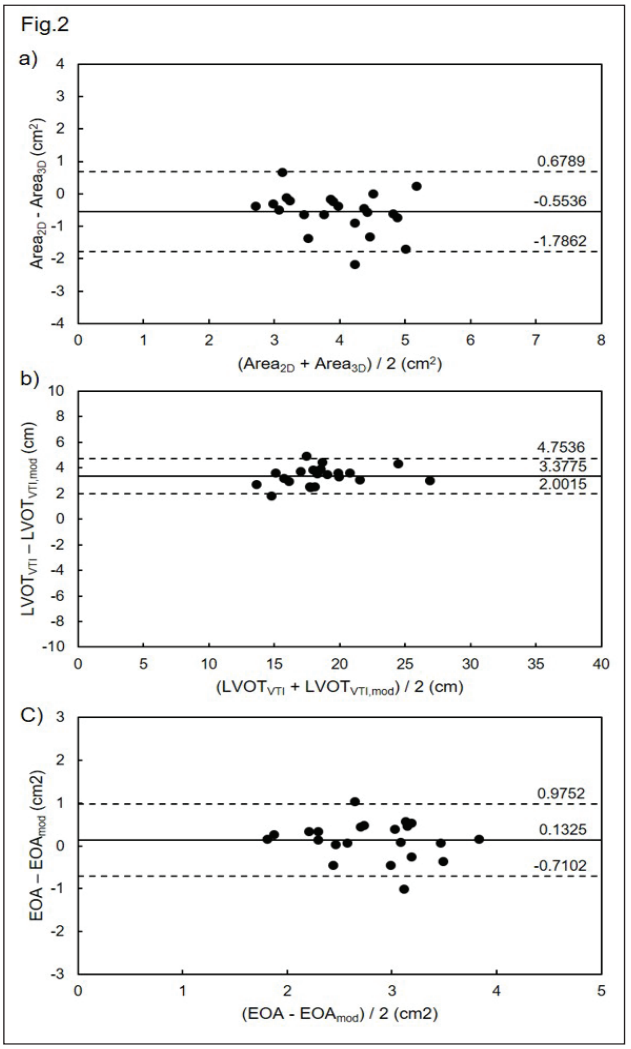

P1-181

Transesophageal Doppler Echocardiography Does Not Accurately Predict Mean Left Atrial Pressure: A Validation Study with Simultaneous Invasive and Noninvasive Measurement

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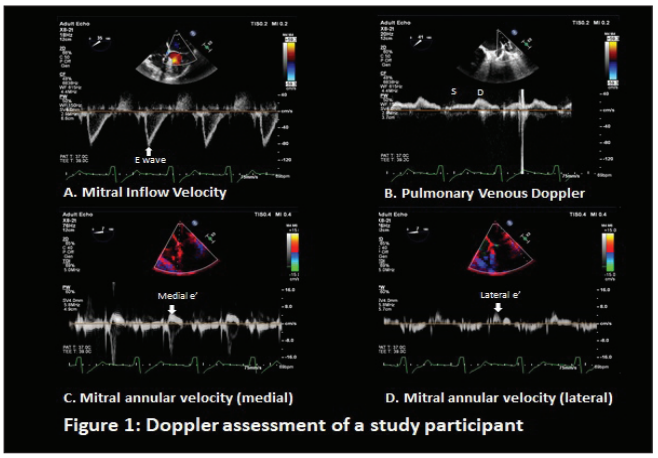
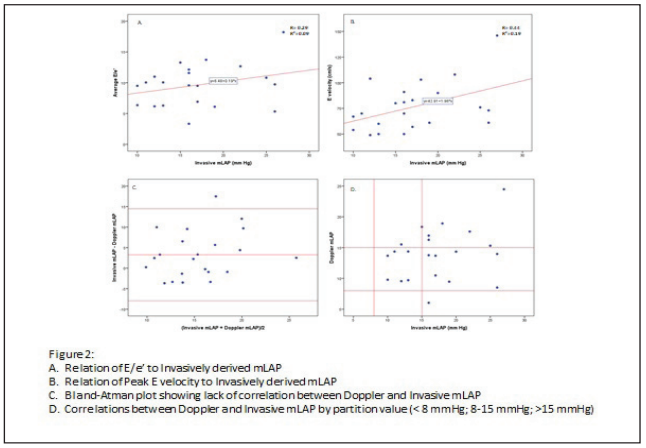
Background: Doppler echocardiographic parameters are routinely used for non-invasive assessment of diastolic function and left atrial pressure (LAP). However, the historical data validating this association is based on pulmonary capillary wedge pressure as a surrogate for mean LAP which may not be accurate. We sought to examine the relationship between transesophageal echo (TEE) derived Doppler parameters and directly measured LA pressure. **Methods:** Twenty-two subjects undergoing left atrial appendage occlusion underwent Doppler evaluation by TEE and direct mean LAP measurement. There was no right to left shunt at the time of pressure measurements as the catheter occluded the foramen ovale. Subjects were divided into groups based on mean LAP (<8mm Hg, 8-15mm Hg and >15mm Hg) for subgroup analysis. We performed linear regression and Bland-Altman analysis to establish a relationship between trans-mitral E velocity, tissue Doppler derived e', E/e' ratio, deceleration time of E wave (DT), iso-volumic relaxation time (IVRT) and pulmonary vein (PV) flow. Doppler mean LAP was calculated by the Nagueh Formula (1.24 x [E/e'] + 1.9). **Results:** The mean age of the group was 73 years, 10 (44%) were female. Nine (41%) participants were in sinus rhythm at the time of the procedure. Mean LVEF was 58 +/- 8%. An example of a study participant's TEE Doppler evaluation is presented in Figure 1. Mean invasive LA pressure was 17 +/-5.4 mm Hg whereas mean Doppler derived mLAP was 13.8 +/-4.2 mm Hg. Doppler derived E velocity, DT, E/e', average e', and IVRT were not associated with mLAP (Figure 2-A, B, C). When partitioned into groups based on mLAP, Doppler mLAP and Invasive mLAP correlated only in 12(54%) subjects (Figure 2D). PV systolic:diastolic ratio <1 was associated with mLAP>15mm Hg (p=0.02). **Conclusion:** TEE derived pulmonary flow reversal accurately predicts elevated mLAP>15mm Hg in subjects with AF however, E/e' is not associated with mLAP. Thus, TEE derived E/e' should not be used for evaluation of filling pressure in this patient population.





P1-182

Peak Left Atrial Strain as a Single Measure for the Non-Invasive Assessment of Left Ventricular Filling Pressures

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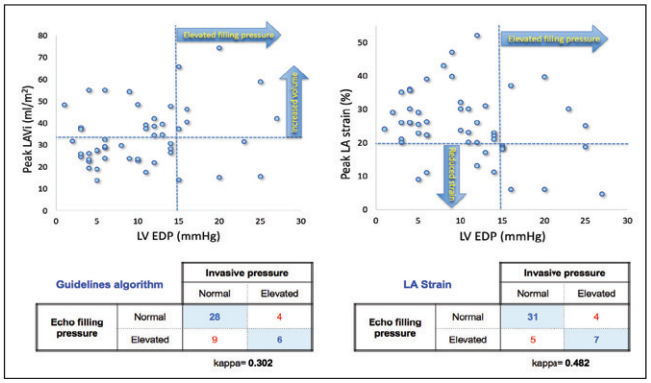
Background: Echocardiographic assessment of left ventricular (LV) filling pressures is performed using a multi-parametric algorithm. Left atrial (LA) strain was recently found to accurately classify the degree of diastolic dysfunction. We hypothesized that LA strain could be used as a stand-alone marker and sought to identify and test a cutoff, which would accurately detect elevated LV pressures. **Methods:** We studied 76 patients with a spectrum of LV function who underwent same-day echocardiogram and invasive left-heart catheterization. Speckle tracking was used to measure peak LA strain. The protocol involved a retrospective derivation group (N=26) and an independent prospective validation cohort (N=50) to derive and then test a peak LA strain cutoff which would identify pre-A-wave LV end-diastolic pressure (LVEDP)>15 mmHg. The guidelines-based assessment of filling pressures and peak LA strain were compared side-by-side against invasive hemodynamic data. **Results:** In the derivation cohort, receiver-operating characteristic analysis showed area under curve of 0.76 and a peak LA strain cutoff <20% was identified as optimal to detect elevated LVEDP. In the validation cohort, peak LA strain demonstrated better agreement with the invasive reference than the individual components used by the guidelines algorithm, such as LA volume, with considerably fewer false positives (Figure, top panels), and also better agreement than the multiparametric guidelines algorithm (81 vs. 72%; Figure bottom panels). The improvement in classification using LA strain compared to the guidelines was more pronounced in subjects with normal LV function (91% versus 81%). **Conclusion:** The use of a peak LA strain to estimate elevated LV filling pressures is more accurate than the

current guidelines. Incorporation of LA strain into the non-invasive assessment of LV diastolic function may improve the detection of elevated filling pressures.



Guidelines algorithm		Invasive pressure	
		Normal	Elevated
Echo filling pressure	Normal	28	4
	Elevated	9	6

kappa= 0.302

LA Strain		Invasive pressure	
		Normal	Elevated
Echo filling pressure	Normal	31	4
	Elevated	5	7

kappa= 0.482

P1-183

Evaluating the Changes of Intra- and Interatrial Mechanical Delay with Age in Normal Adults by Dual Doppler Echocardiography

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Background: The availability of dual Doppler echocardiography, which facilitates the simultaneous recording of Doppler waveforms at 2 different sites during the same beat, has enhanced our ability to non-invasively assess single-beat atrial mechanical delay. We sought to evaluate the changes of intra- and interatrial mechanical delay with age in normal adults by dual Doppler echocrdiography and discuss the feasibility of dual Doppler echocrdiography in assessing atrial mechanical delay. **Methods:** 114 healthy volunteers were divided into three groups according to age: group A (18~39 years old, n=40), group B (40~59 years old, n=42), group C (60~79 years old, n=32). The time interval of the onset of a' wave between mitral annular septal and lateral site was used to evaluate intra-left atrial mechanical delay (T1) by dual Doppler echocrdiography. The time intervals from the onset of a' wave at tricuspid annular right ventricular free wall site to a' wave at tricuspid annular septal site and mitral annular lateral site were used to evaluate intra-right atrial and interatrial mechanical delay (T2 and T3). With traditional Doppler technique, the time intervals from the onset of P wave to the onset of a' wave at the mitral annular lateral site (P-L), the mitral annular septal site (P-S), the tricuspid annular right ventricular free wall site (P-RVFW) were measured. The time differences between P-L and P-S, between P-S and P-RVFW, between P-L and P-RVFW were t1 (intra-left atrial mechanical delay), t2 (intra-right atrial mechanical delay), t3 (interatrial mechanical delay). **Results:** ① T1, T2, T3 and t1, t2, t3 increased with age among group A, B and C (all P<0.05). ② The parameters of atrial mechanical delay in dual Doppler echocrdiography were concordant with that in traditional Doppler technique. And the measurements of two methods were correlated (r=0.78, P<0.01). Assessing atrial mechanical delay with dual Doppler echocardiography took less time than that with traditional Doppler technique (P<0.05). For inter- and intraobservers, the interclass correlation coefficient with dual Doppler echocrdiography was higher and 95% confidence interval range was smaller (P<0.05). **Conclusion:** The intra- and interatrial mechanical delay prolongs with age in normal adults. Dual Doppler echocrdiography is feasible in evaluating atrial mechanical delay, which can provide more repeatable measurements and can be a new prospective and time-saving method to assess atrial mechanical delay.

P1-184

Assessment of Left Ventricular Diastolic Function in the Normal Healthy Asian Elderly

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Background: Age-associated changes in left ventricular (LV) diastolic function are well recognized and diastolic dysfunction is a major cause of heart failure in the elderly. There is limited data characterizing the measurements of diastolic function in the normal elderly population. Our aim is to study the relationship between aging and parameters of LV diastolic function in an elderly healthy Asian population. **Methods:** Retrospective review of transthoracic echocardiogram (TTE) database in National Heart Centre Singapore from Jan 2015 to Dec 2016 was performed and included patients with symptoms suspected of cardiac etiology. Exclusion criteria included valvular disease, abnormal ventricular systolic function, LV hypertrophy, hypertension, diabetes mellitus, ischemic heart disease, cerebral vascular accidents, atrial fibrillation, chronic kidney disease, chronic obstructive pulmonary disease and connective tissue disease. TTE was performed and analyzed according to the American Society of Echocardiography (ASE) guidelines. **Results:** A total of 245 subjects were studied (64±9yo, 63% female) and divided into three age groups (table 1). With increased age, mitral inflow E velocity gets smaller (p<0.05) and A velocity gets taller (P<0.01), resulting in reduction in E/A ratio (p<0.05); there is lengthening of deceleration time (p<0.05), reduction of tissue Doppler septal e' velocity (p<0.01), and a trend towards an increase in LA volume index. There is no significant difference between genders except smaller LV volume index with increasing age in females (p<0.01). Using the new ASE 2017 guideline to assess LV diastolic function, the majority of patients were categorised as normal diastolic function (96%, 95% and 90% in Group A, B and C). Although the number of indeterminate cases increases with age (4%, 5% and 10% in Group A, B and C), none of them had diastolic dysfunction. **Conclusion:** In this healthy, normotensive elderly Asian cohort, sensitive markers for age related diastolic function include: mitral inflow E velocity A velocity, E/A ratio, deceleration time, tissue Doppler septal e' velocity. There is also a trend towards increased LA volume with age. This is consistent with the Western data. New ASE guideline remains a good screening tool for diastolic dysfunction in the elderly Asian population.

Table 1. Echocardiographic parameters based on Age Groups

	Group A	Group B	Group C
	50-58yo (n=79)	59-67yo (n=83)	68-91yo (n=83)
Gender: Female (%)	68	64	57
IVSD (mm)	8.3 ± 1.1	8.5 ± 1.4	8.7 ± 1.2
LVIDD (mm)	44.6 ± 4.9	43.8 ± 4.6	44.6 ± 5.3
LVIDS (mm)	27.7 ± 4.0	26.8 ± 4.1	27.2 ± 5.4
LVPWD (mm)	8.1 ± 1.2	8.1 ± 1.2	8.2 ± 1.0
LV mass index (g/m2)	71.4 ± 14.9	74.5 ± 14.8	74.5 ± 16.4
LVEDV index (ml/m2)	46.1±10.2	44.5±10.8	38.5±8.3**††
LVESV index (ml/m2)	18.9±7.5	16.8±4.6	14.7±4.1**
LVEF 2D (%)	61.8 ± 4.5	62.5 ± 4.5	62.4 ± 4.4
Diastolic function assessment			
Epeak (cm/s)	76.7 ± 18.9	78.4± 14.8	72.5± 19.2†
Apeak (cm/s)	60.3 ± 17.9	67.4 ± 20.7	78.9 ± 44.0**†
E/A ratio	1.4 ± 0.5	1.3 ± 0.5	1.1 ± 0.9*
D Time (ms)	196.7 ± 36.3	199.4 ± 43.9	219.9 ± 49.5**††
Septal e' (cm)	9.2± 2.6	8.8 ± 2.9	7.4 ± 2.6**††
Lateral e' (cm)	11.3 ± 3.4	10.9 ± 3.3	10.1 ± 8.5
Average septal and lateral E/e'	8.2±3.3	8.7±2.6	9.7±3.5**†
LA Vol index (ml/m2)	23.6 ± 8.5	23.8 ± 6.7	25.1 ± 7.6
TRVmax (ms)	2.2 ± 0.2	2.3 ± 0.3	2.3 ± 0.3
Average septal and lateral E/e' >14, %	0	0	0
Septal e' < 7cm, %	18	19	45
Lateral e' < 10cm, %	29	35	61
Septal e' < 7 cm or Lateral e' <10cm, %	32	36	65
TR Vmax >2.8 m/s, %	3	1	4
LA volume index >34ml/m2, %	6	5	11
Normal diastolic function (< 50% positive, %)	96	95	90
Indeterminate diastolic function (=50% positive, %)	4	5	10
Diastolic dysfunction (>50% positive, %)	0	0	0

* comparison between age groups: * p<0.05, **p<0.01, compared to Group A, †p<0.05,‡ p<0.01 compared to Group B

P1-185

The Clinical Significance of Diastolic-Systolic Velocity Ratio and Coronary Flow Reserve Detected on Non-Invasive Doppler Echocardiography in Patients with Angiographically 50-75% Stenosis of Left Anterior Descending Artery

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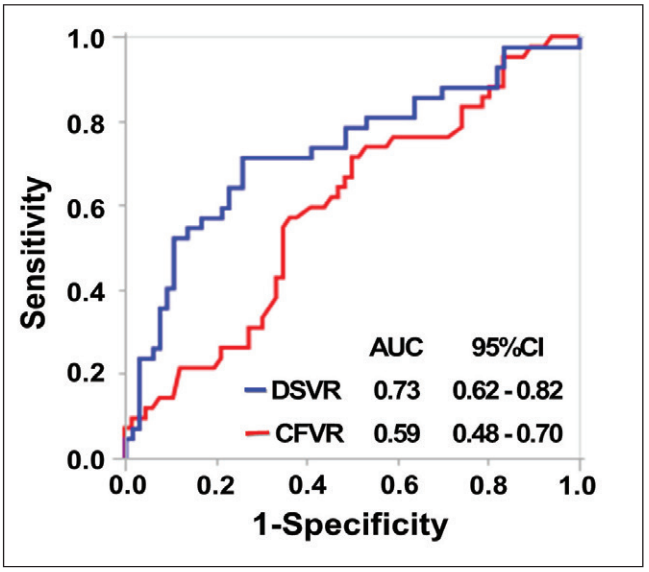
Background: Coronary flow measurements by transthoracic Doppler echocardiography is a noninvasive tool to assess coronary stenosis and estimate future coronary events. Fractional flow reserve (FFR) by pressure wire has been the gold standard to assess the functional coronary stenosis. However, the reliability of coronary flow parameters by non-invasive Doppler echocardiography remains unsettled. The aim of this study was to identify the variables of significant myocardial ischemia detected on Doppler echocardiography at the lesion of left anterior descending artery (LAD). **Methods:** From January 2012 to December 2017, 144 consecutive patients (mean age 71 ± 9 years; 30 women) with angiographically intermediate stenosis (between 50% and 75% diameter stenosis by visual assessment) at the proximal segment of LAD, who underwent both invasive FFR and coronary flow measurements by Doppler echocardiography with or without adenosine loading (adenosine triphosphate [0.14 $mg \cdot kg^{-1} \cdot min^{-1}$]) within six months were retrospectively analyzed in this study. **Results:** The mean FFR and coronary flow velocity reserve (CFVR) were 0.76 ± 0.08 and 2.28 ± 0.65, respectively. Among these patients, diastolic-systolic peak velocity ratio in hyperemia state (DSVR) could be evaluated in 114 of 144 patients (79%). DSVR was significantly higher in patients with preserved FFR (FFR ≥ 0.75; 1.68 ± 0.49) compared with those with reduced FFR (FFR < 0.75; 1.35 ± 0.52, p = 0.001). There was a better correlation between DSVR and FFR (R^2 = 0.114, p < 0.001) than between CFR and FFR (R^2 = 0.049, p = 0.010). Receiver operating characteristic (ROC) curves showed DSVR = 1.45 and CFVR = 2.26

was the optimal cutoff value to predict FFR < 0.75. DSVR showed the higher C-statistics (0.73, 95% confidence interval (CI) 0.62-0.82, sensitivity 71%, and specificity 74%, positive predictive value (PPV) 64%, negative predictive value (NPV) 80%, respectively) compared to CFVR (0.59, 95%CI 0.48-0.70, sensitivity 73%, and specificity 53%, PPV 48%, NPV 74%, respectively; p = 0.03). **Conclusions:** In patients with intermediate LAD stenosis, DSVR had significantly correlated with FFR than CFVR. Reduced DSVR may be pathophysiological surrogates for excluding functionally significant stenosis in LAD lesions.



P1-186

Pre- and Post-Pericardiocentesis Echo-Doppler Features of Effusive-Constrictive Pericarditis Compared to Cardiac Tamponade and Constrictive Pericarditis

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Background: The echo-Doppler features of constrictive pericarditis (CP) and cardiac tamponade have been well studied but the echocardiographic findings in effusive-constrictive pericarditis (ECP) are still largely unknown. Moreover, it would be helpful if ECP could be predicted non-invasively at the time of pericardiocentesis. **Methods:** We identified 22 patients diagnosed at our institution between 2002 and 2016 who had persistent elevation of jugular venous pressure post-pericardiocentesis. We compared them to 30 patients with CP and 30 patients with cardiac tamponade who had normalization of venous pressure post-pericardiocentesis. All patients were in sinus rhythm. **Results:** Mean age was 57±18 years in the ECP group; 36% were females. Most ECP and cardiac tamponade cases were idiopathic (39% and 33%, respectively). Prior to pericardiocentesis, medial and lateral e' velocities were higher in ECP compared to tamponade (9.8±3.3 versus 6.2±1.8 cm/s; p=.0007 and 8.5±3.2 versus 5.8±2.7; p=.04 cm/s, respectively). Inspiratory (1.23±0.5 versus 0.84±0.2, p=.002) and expiratory (1.41±0.7 versus 0.94±0.3, p=.01)mitral E/A ratios were higher in ECP compared to tamponade, but lower than those observed in CP (inspiratory E/A 1.65±0.8 p=.045 and expiratory E/A 1.9±0.8, p=.01). Both ECP and tamponade patients had markedly decreased hepatic vein (HV) diastolic forward flow velocities. Mean expiratory IVC diameter was higher in ECP compared to tamponade (2.6±0.4 versus 2.3±0.5 cm, p=.047), but there were no differences in inspiratory diameter or IVC collapsibility index. Post-pericardiocentesis, mean inspiratory and expiratory E/A ratios increased in both tamponade (0.84±0.3 to 1.37±0.6, p=.0005 and 0.94±0.3 to 1.63±0.7. p=.0002, respectively) and ECP (1.23±0.5 to 1.63±0.6, p=.048 and 1.41±0.7 to 1.9±0.7, p=.03, respectively) groups. HV diastolic forward flow velocities markedly increased in both ECP and tamponade. HV diastolic reversal velocities decreased in tamponade but were unchanged in ECP, being significantly higher in the latter group (34±9 versus 17±6, p=.0002). A persistently dilated IVC was seen more frequently in the ECP (70%) than in the tamponade group (26%, p=.004). During median follow-up of 481 days, 3 patients required pericardiectomy for CP; they were all in the ECP group (14% of ECP cases). **Conclusion:** ECP has unique echo-Doppler features that distinguish it from both CP and tamponade. Our findings suggest that ECP could be diagnosed by echocardiography even prior to pericardiocentesis. ECP appears to have a good prognosis, particularly in patients presenting acutely.

P1-187

Correlation of Echocardiographic Parameters of Right Atrial Pressure with Invasively Measured Mean Right Atrial Pressure: Does Anything Work?

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Introduction: Right atrial pressure (RAP) assessment is an integral part of everyday echocardiographic (echo) examination. RAP assessment is important as it provides information about volume status and it is incorporated in the calculation of the non-invasive pulmonary systolic pressure. In this study we are assessing the correlation of the echocardiographic parameters of RAP with the invasively derived mean RAP. **Methods:** Study cohort consists of 90 consecutive patients scheduled for clinically indicated right heart catheterization for whom a same day echo was performed. Those with severe tricuspid regurgitation or tricuspid valve repair/replacement, and those who were not in sinus rhythm were excluded (n=67 included for the analysis). Echo RAP parameters (inferior vena cava (IVC) maximum (max) diameter, IVC compressibility (defined as (IVC max diameter-IVC minimum diameter)/IVC max diameter), hepatic vein systolic (S) and diastolic flow (D) velocities, tricuspid annulus e' velocity, tricuspid inflow E velocity, and tricuspid E/e' were compared to invasive mean RAP. Univariate linear regression analysis was performed first and followed by a stepwise-forward multivariate regression model to include the variables that were statistically significant in the initial univariate analysis. **Results:** Average age of the cohort is 53.2±13.4 years with 55.2% males, and 83.6% were heart transplant recipients. Invasive mean RAP was 7.69±4.52 mmHg. Univariate regression analysis showed significant correlation for only IVC max diameter and IVC compressibility with the invasive mean RAP, with coefficient of determination (R^2) of 0.302, p<0.0001, and 0.079, p=0.03, respectively. Otherwise, R^2 was not significant for all the other variables with 0.003 for E/e' (p=0.63), 0.1 for hepatic S velocity (p=0.11), and 0.05 for hepatic D velocity (p=0.23). After performing the multivariate regression model (R^2 for the model is 0.31, p<0.0001), only IVC max diameter stayed significant with p<0.0001 but the IVC compressibility became non-significant (p=0.56). **Conclusion:** In our cohort, the only echo parameter that correlated with invasive mean RAP was IVC max diameter. However, the correlation was only modest at best. Therefore, the noninvasive assessment of RAP is still challenging and the need for more accurate parameters is warranted.

P1-188

Low Stroke Volume "Syndrome" in the Echocardiography Laboratory: An Unrecognized Reality

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Background: Accurate calculation of stroke volume (SV) by two-dimensional Doppler echocardiography is important for the assessment of valvular disease, determination of outcome, and choice of appropriate intervention for low-flow, low-gradient aortic stenosis with normal left ventricular ejection fraction (LVEF). However, the prevalence of low stroke volume (LSV) among patients with normal LV function and without valvular disease is unknown. **Methods:** Three hundred consecutive patients with LVEF of ≥55% and normal valvular function were retrospectively analyzed. In accordance with routine practice in US echocardiography laboratories, two-dimensional Doppler echocardiography (2D echo) was performed and SV were calculated using the continuity equation and 2D echo as recommended by the American Society of Echocardiography. SV was indexed by body surface area (SVi). Patients were divided into a LSV group (SVi of <35 ml/m^2) and normal SV group (NSV, SVi≥35ml/m^2). Clinical characteristics and 2D Doppler echocardiography parameters were compared between LSV and NSV groups. **Results:** Mean age was 60±17 years (44% males) and LVEF was 60 ± 4% in this study population. One hundred sixty-one (54%) of the patients had SVI <35 ml/m^2. SVi calculated by 2D echo was significantly lower than SVi by Doppler in both LSV (24±9 vs. 28±5 ml, p<0.01) and NSV (28±9 vs. 44±9 ml, p<0.01) groups. Neither group had significant LV hypertrophy. LV outflow tract velocity-time integral (VTI) measured by pulsed wave Doppler, and aortic valve peak velocity and VTI by continuous wave Doppler were significantly lower in the LSV group than NSV group, indicating truly different flow status. Calculated aortic valve area was smaller in the LSV patients than the NSV patients (**Table**), although mean gradient was also lower in the LSV patients (4.5 ± 2.7 vs. 5.2 ± 3.3 mmHg). **Conclusion:** Using the current cutoff value, LSV syndrome was very common in patients who had normal LVEF and normal valves assessed by 2D Doppler echo. This unrecognized reality poses a great challenge to the quantitative assessment of valvular stenosis or regurgitation, particularly for low gradient severe aortic stenosis. Further multicenter studies of methodology, standardization and individualized cutoff values for LSV are warranted.

Comparisons between LSV and NSV groups

	Septal Thickness (mm)	LVOT (cm)	2D SVi (ml/m^2)	Doppler SVi (ml/m^2)	LVOT VTI (cm)	Aortic valve velocity (cm/s)	Aortic valve VTI (cm)	AVA index (cm^2/m^2)
LSV	11±2	2.0±0.2	24±9	28±5	18±4	154±39	20±7	1.2±0.3
NSV	11±2	2.1±0.2	28±9	44±8	23±5	136±32	30±9	1.6±0.4
P value	>0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Poster Session 1 (P1)

Sunday, June 24, 2018

P1-189

Left Ventricular Suction During Exercise was Associated with Exercise Capacity in Patients with Heart Failure Regardless of Ejection Fraction

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Background: Exercise intolerance is an independent predictor of all-cause mortality in heart failure patients regardless of left ventricular (LV) ejection fraction (EF). In normal conditions, LV suction augments early diastolic intra left ventricular pressure difference (IVPD) and maintains or even increases diastolic filling during exercise, resulting in higher exercise capacity. However, the impact of LV suction during exercise on exercise capacity in heart failure patients has not been fully elucidated. **Methods:** The cardiopulmonary exercise testing and exercise-stress echocardiography were performed in 47 heart failure patients (60±16 years old, ischemic etiology 17%) within 7 days. Peak oxygen uptake (VO_2) was measured by a respiratory gas analysis with an upright bicycle ergometer as a parameter of exercise capacity. Apical 4- and 2-chamber views and color M-mode Doppler image of LV inflow were obtained at rest and peak exercise. LV EF was measured by the method of disks. The early-diastolic IVPD from mitral annulus to the LV apex was determined using color M-mode Doppler data to integrate the Euler equation as a parameter of LV suction. **Results:** LV EF was 39±15% at rest in overall heart failure patients; 27 patients had a reduced LV EF (<40%, HFrEF), whereas 20 patients had a relatively preserved LV EF (≥40%, HFpEF). Peak VO_2 was lower in HFrEF than in HFpEF (16±5 vs 20±6 mL/min/kg, P<0.05). IVPD at rest was also lower in HFrEF than in HFpEF (1.6±1.0 vs 2.6±1.0 mmHg, P<0.05). During exercise, LV EF (HFrEF: 30±9% to 33±13%, HFpEF: 54±12% to 63±15%) and IVPD (HFrEF: 1.6±1.0 to 3.1±1.4 mmHg, HFpEF: 2.6±1.0 to 5.2±2.7 mmHg) were significantly increased in both groups (P<0.05 for all). In overall patients, IVPD at peak exercise significantly correlated with peak VO_2 (R=0.70, P<0.01), whereas IVPD at rest did not. LV EF at peak exercise also correlated with peak VO_2 (R=0.36, P<0.05). In a multivariable analysis, IVPD at peak exercise determined peak VO_2 independently from LV EF (IVPD: β=0.67, P<0.01; LV EF: β=0.03, NS). Moreover, similar findings were observed even in either types of heart failure (Table). **Conclusion:** LV suction at peak exercise was closely associated with whole-body exercise capacity in heart failure patients regardless of LV EF.

Correlations of IVPD and LV EF at peak exercise to peak VO_2

	HFrEF				HFpEF			
	Univariable		Multivariable		Univariable		Multivariable	
Variables	R	P value	β	P value	R	P value	β	P value
IVPD	0.71	<0.01	0.51	0.02	0.67	<0.01	0.67	<0.01
LV EF	0.60	0.01	0.27	NS	0.02	NS	0.07	NS

P1-190

Mechanical Dyssynchrony Parameters and Superresponse to Cardiac Resynchronization Therapy in Patients with Congestive Heart Failure

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Background: Some patients with congestive heart failure (CHF) have greater improvement of cardiac remodeling after cardiac resynchronization therapy (CRT) and they are identified as super-responders (SR). It remains unclear if echocardiographic cardiac dyssynchrony parameters could accurately predict super-response to CRT. **Purpose:** To evaluate potential echocardiographic predictors related to super-response after CRT. **Methods:** 59 CRT patients (mean age 52.9±9.0 years, 88% men) with CHF (54% ischemic and 46% non-ischemic etiology) and II-III NYHA functional class were enrolled. After 6 months patients were divided into SR (reduction in left ventricular end-systolic volume (LVESV) ≥30%, n=20) and non-SR (reduction of LVESV <30%, n=39). To assess mechanical dyssynchrony we evaluated interventricular mechanical delay, duration of left ventricular pre-ejection period (LVPEP) by Doppler ultrasound velocity measurements of blood flow, the maximum delay between peak systolic velocities of the septal and lateral walls of left ventricle by Doppler tissue imaging. Systolic dyssynchrony index was assessed by 3D echocardiography. **Results:** Both groups demonstrated significant improvement of NYHA functional class, reductions of left ventricular ejection fraction and LVESV. All parameters of mechanical dyssynchrony were significantly higher in SR. Multiple logistic regression analysis showed that LVPEP was an independent predictor for CRT super-response (95% confidence interval [CI] 1.007-1.055; p=0.011). In ROC curve analysis LVPEP demonstrated sensitivity 73.7% and specificity 75% (AUC 0.753; p=0.002) in prediction of response to CRT. **Conclusion:** In patients with CHF greater mechanical dyssynchrony is associated with super-response to CRT. LVPEP can be used as an independent predictor of CRT super-response.

P1-191

Paradoxical Low Gradient Aortic Stenosis Reclassified Using Hybrid Continuity Equation by MultiDectector CT: Insights Into Diastolic Function and Post TAVR Outcomes

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Background: Paradoxical low flow low gradient aortic stenosis (PLF-AS) is a complex clinical entity posing challenges in diagnosis and management. Left ventricular outflow tract (LVOT) diameter underestimation is a key reason for inaccuracies in quantitation. We investigated the utility of a hybrid modified continuity equation using multidetector computed tomography (MDCT) derived LVOT diameter/cross sectional area and Doppler echocardiography (DE) to study the impact of reclassifying patients with severe PLF-AS. We further analyzed differences in diastolic parameters and outcomes in reclassified patients post-transcatheter aortic valve replacement (TAVR). **Methods:** Patients being evaluated for TAVR between January 2015 to July 2017 with both DE and MDCT data available were retrospectively reviewed. PLF-AS defined as valve area (AVA) < 1 cm^2 by DE, left ventricular EF ≥ 50%, stroke volume index (SVI) < 35 mL/m^2, and mean aortic pressure gradient ≤ 40 mmHg by DE. AVA was recalculated substituting MDCT LVOT data into the equation. The cut off for severe AS with the hybrid equation was set as < 1.2 cm^2 as previously reported. Diastolic Parameters and TAVR outcomes (NYHA class, mortality and hospital admissions for CHF) were analyzed. **Results:** 67 patients were included in the analysis (mean age 79.9 ± 8.6 years, 49% female). Twenty four percent (n=16) of patients were ultimately reclassified from severe to moderate AS by merging MDCT and DE data. There was a significantly higher number of patients with diastolic dysfunction (grade I or higher) (95% vs 75%; p=.03) and restrictive physiology (grade 3 diastolic dysfunction) (33% vs. 8%; p=.032) in those who remained in the severe AS group using the hybrid equation. NYHA class prior to valve replacement was worse in the patients in the severe category (3.05 vs. 2.6; p=0.013). At a mean f/u of 19 months 67% (n=45) underwent TAVR (11 reclassified as moderate AS and 34 as severe AS). Those who remained in the severe AS range had a greater improvement in their SVI (35.5 vs. 26.9 p<.001) after TAVR, and average improvement in NYHA class was significantly better in the severe AS group (1.63 vs 1.11 p=0.042). There was no significant difference between the two groups with regards to CHF hospitalization or all-cause mortality. **Conclusion:** Merging MDCT with DE reclassifies nearly a quarter of patients with severe PLF-AS into the moderate category. Patients with severe AS per hybrid equation have more advanced DD and had a more significant improvement in NYHA class and SVI. Future studies will need to assess if proceeding or deferring interventions can be based on combining MDCT and DE.

P1-192

Explore the Application Value of Vector Flow Mapping in Assessing the Degrees of Coronary Artery Stenosis

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Background: To quantify the left ventricular flow field characteristics of different phases of cardiac cycle in patients with different degrees of coronary artery stenosis by using vector flow mapping (VFM), and to explore the value of quantitative parameters of VFM in diagnosis of degrees of coronary artery stenosis in patients with coronary heart disease. **Methods:** Eighty-five patients with coronary artery stenosis showed by coronary angiography served as case group. According to the results of coronary angiography, all the patients of case group were divided into three groups : mild stenosis group, moderate stenosis group and severe stenosis group. Forty-five healthy adult volunteers selected as control group. The quantitative parameters, including average energy loss (EL-base, EL-mid, EL-apex) and circulation (vortex area, circulation) were measured in the different periods of vector flow mapping imaging mode. The difference of parameters were evaluated between case group and control group during different periods. E/e′ was derived via dual-Doppler imaging technology And correlation was analyzed between aEL, circulation and E/e′, separately. **Results:** ① Compared with the control group, aEL in global and regional segment of left ventricle in the severe stenosis group were significantly increased during isovolumetric relaxation period, reduced filling period, atrial systolic phase and isovolumic contraction period (P<0.05). And the aEL in global and regional segment of left ventricular in the moderate stenosis group were significantly increased during reduced filling period, atrial systolic phase and isovolumic contraction period (P<0.05). And the aEL in global and regional segment of left ventricular in the mild stenosis group were significantly increased during reduced filling period (P<0.05). ② Compared with the control group, the vortex area and circulation intensity in left ventricular of the severe stenosis group were significantly increased during isovolumetric relaxation period, reduced filling period, atrial systolic phase and isovolumic contraction period(P<0.05). ③ In case group, aEL had a good correlation with E/e′ at total and

partial segment of rapid filling phase and atrial systolic phase. And the vortex area and circulation intensity had a good correlation with E/e´ during reduced filling period and atrial systolic phase. **Conclusions:** VFM can effectively evaluate the flow field characteristics of left ventricle in patients with coronary heart disease. The quantitative parameters of VFM can reflect the extent of coronary artery stenosis to some extent.

P1-193

Differentiating Pre-Capillary and Post-Capillary Pulmonary Hypertension by Doppler Echocardiography in a Large Real-World Database

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Background: Pulmonary hypertension is common, dangerous and has multiple causes. Vasodilator therapy has significantly improved the prognosis of patients with pulmonary arterial hypertension, but the diagnosis can be challenging, requiring right heart catheterisation (RHC). Differentiating pre-capillary pulmonary hypertension (prePH) and post-capillary pulmonary hypertension (postPH) and measuring pulmonary vascular resistance are key steps for diagnosing pulmonary arterial hypertension. A novel echocardiographic parameter, the pulmonary to left atrial ratio (ePLAR), which is derived from the tricuspid regurgitation velocity (TRV) divided by the ratio between the early diastolic filling velocity and the early mitral annulus velocity (E/e'), i.e., ePLAR=TRV/E/e', has been described as a surrogate for RHC. This retrospective cohort study tests the ability of ePLAR to differentiate prePH and postPH, in a large real world database. **Methods:** The data from all RHCs performed within 5 years' period (January 2010 to February 2015) was extracted from the hospital's database. The closest corresponding echocardiograms were searched in the national echo database Australia (NEDA) using the identifiers from RHC data. **Results:** 887 pairs of echos and RHCs were merged and analysed in our study. The median time difference between RHC and echocardiography was 7 (IQR 1-62) days. The ePLAR was calculable in 184 cases (21%). Median (IQR) ePLAR values were significantly different between prePH and postPH groups: 0.35 (0.13-0.50) m/s vs 0.17 (0.12-0.23) m/s (P=0.003), despite both groups having similar mean pulmonary artery pressures. The optimal ePLAR cut-off of 0.28m/s had a positive predictive value of 94% for postPH, with sensitivity of 83% and specificity of 67%. **Conclusions:** ePLAR helps to discriminate postPH from prePH and may be useful in evaluating these patients.

P1-194

Heart Failure with Reduced Ejection Fraction (HFrEF) in Young Patients Has Unique Clinical and Sociodemographic Features: An Urban and Multiracial Observation

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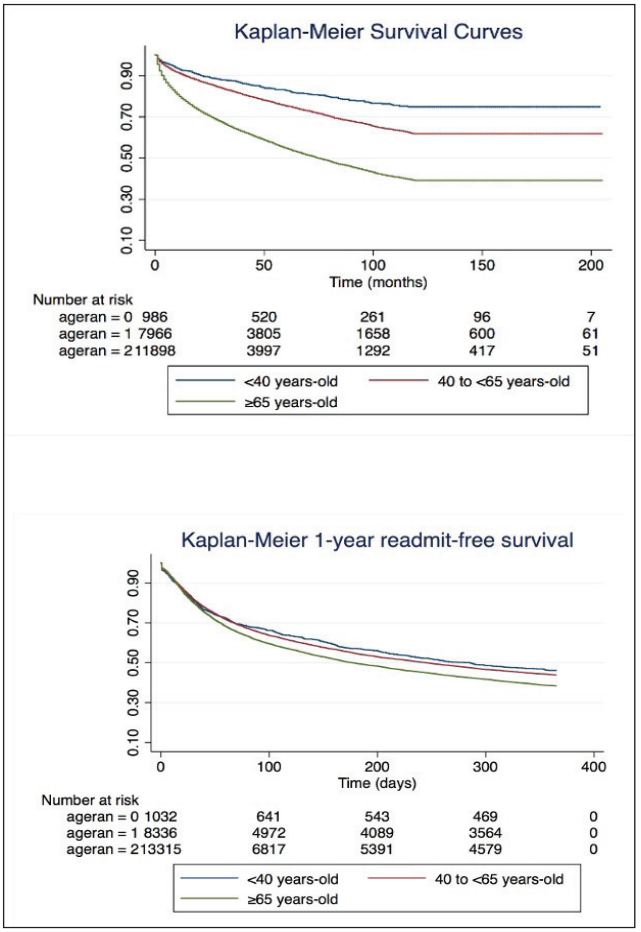
Background: Young patients with HFrEF might present distinctive clinical phenotypes due to different etiologies and other age-related comorbidities comparing with older patients. Studies of HFrEF in young individuals remain scant, especially in racial-ethnically diverse communities. **Methods:** Patients with HF diagnosis upon inpatient discharge at Montefiore Medical Center, Bronx, New York between 2000-2016, with an EF <40% were included. Patients were divided into three age groups: young (18-39 years), middle-age (40-64 years), and elderly (> 64 years). Socioeconomic score (SES) was a summary Z-score that combined wealth and income and displayed as above (positive) or below (negative) mean SES in New York state. All cause mortality was obtained until December 31st, 2017. Clinical characteristics were compared among groups using chi-square and ANOVA tests. Unadjusted and sex-adjusted Cox proportional models were performed to evaluate risk of mortality and 1-year readmission among different age groups. **Results:** A total of 1,032, 8,336 and 13,315 young, middle-age and elderly patients were included in the study. Median follow-up was 36 (14-69) months. Young patients were predominantly Blacks, and had significantly lower SES compared with middle-age and elderly patients. Young individuals had significantly lower proportions of ischemic heart disease and atrial fibrillation, but higher proportions of dilated, alcoholic and peripartum cardiomyopathies. They had larger left ventricular chamber size but lower pro-NT-BNP levels (Table). Young patients had 78% and 31% lower risk of mortality and 1-year readmission rates, respectively, than those of elderly groups ($p < 0.001$) (Figure). **Conclusion:** Young patients with HFrEF have distinct baseline characteristics, racial distribution, lower SES and worse LV dilatation but a better survival outcome than older patients. Age-specific preventive and therapeutic interventions should therefore be explored.

Table 1. Baseline characteristics of the young HFrEF patients comparing to older age groups.

	Young (N = 1032)	Mid-age (N = 8336)	Elderly (N = 13,315)	P-value
Age (mean±SD)	32.5±5.5	54.9±6.5	77.8±8.3	<0.001
Male, n(%)	624 (60.5)	5,323 (63.9)	6,848 (51.4)	<0.001
Race, n(%)				< 0.001
Caucasian	72 (8.0%)	228 (13.2%)	666 (31.4%)	
Non-Hispanic Black	107 (43.7%)	583 (37.1%)	586 (27.5%)	
Hispanic	59 (26.0%)	383 (24.4%)	467 (20.0%)	
Other races	37 (23.3%)	307 (24.5%)	361 (21.1%)	
SES, mean (SD)	-3.63 (2.83)	-3.32 (2.88)	-2.64 (2.89)	< 0.001
IHD, n(%)	146(14.2%)	3,648 (43.8%)	7,868 (59.1%)	< 0.001
DCM, n(%)	14 (6.45%)	138 (9.19%)	316 (15.0%)	< 0.001
VHD, n(%)	191 (18.5%)	1,659 (19.9%)	3,682 (27.7%)	
Alcoholic CM, n(%)	17 (1.65%)	121 (1.45%)	44 (0.33%)	< 0.001
Peripartum CM, n(%)	32 (3.1%)	3 (0.04%)	0 (0%)	< 0.001
Cocaine abuse, n(%)	1032 (5.5%)	728 (8.7%)	131 (1.0%)	< 0.001
AF, n(%)	114 (11.0%)	1844 (22.1%)	5,322 (40.0%)	< 0.001
HTN, n(%)	422 (40.9%)	5,290 (63.5%)	9,765 (73.3%)	< 0.001
DM, n(%)	171 (16.6%)	3,400 (40.8%)	5,646 (42.4%)	< 0.001
CKD, n(%)	199 (19.3%)	2,170 (26.0%)	4,445 (33.4%)	< 0.001
***HF therapies*, n(%)**				
Beta-blockers	621 (60.2%)	5,097 (61.1%)	6,712 (50.1%)	< 0.001
ACEI/ARB	531 (51.5%)	4,265 (51.2%)	5,196 (39.0%)	< 0.001
H/I	158 (15.3%)	1,127 (13.5%)	1,293 (9.7%)	< 0.001
MRA	233 (22.6%)	800 (16.8%)	1,177 (8.8%)	< 0.001
AICD	196 (19.0%)	1795 (21.5%)	1,892 (14.2%)	< 0.001
Heart Transplant	55 (5.3%)	200 (2.4%)	49 (0.37%)	< 0.001
***Echocardiography*, mean±SD**				
EF (%)	28.0±8.7	29.4±8.2	30.6±7.5	< 0.001
LVESD (mm)	48.6±12.8	45.2±11.8	40.4±13.0	< 0.001
LVEDD (mm)	59.0±11.6	57.0±56.1	51.9±10.5	< 0.001
LAV (ml)	82.5±38.0	78.0±33.1	77.0±32.2	< 0.001
Pro-NT-BNP (ng/ml), mean (IQR)	2,840 (888-7436)	3,137 (1,109-9,173)	5,616 (2,074-14,890)	< 0.001

SES, socioeconomic status; **IHD**, ischemic heart disease; **DCM**, dilated cardiomyopathy; **VHD**, valvular heart disease; **CM**, cardiomyopathy; **AF**, atrial fibrillation; **HTN**, hypertension; **DM**, diabetes; **CKD**, chronic kidney disease; **ACEI**, angiotensinogen converter enzyme inhibitor; **ARB**: angiotensin receptor blocker; **H/I**, hydralazine/isosorbide dinitrate; **MRA**, mineralocorticoid receptor antagonist; **AICD**, automatic implantable cardioverter-defibrillator; **EF**, ejection fraction; **LVESD**, left ventricular end-systolic diameter; **LVEDD**, left ventricular end-diastolic diameter. **LAV**, left atrial volume; IQR, interquartile range.



Poster Session 1 (P1)

Sunday, June 24, 2018

P1-195

Increased Risk of Cardiac Death and Myocardial Infarction in Renal Transplant Recipients with Pre-Transplant Diastolic Dysfunction

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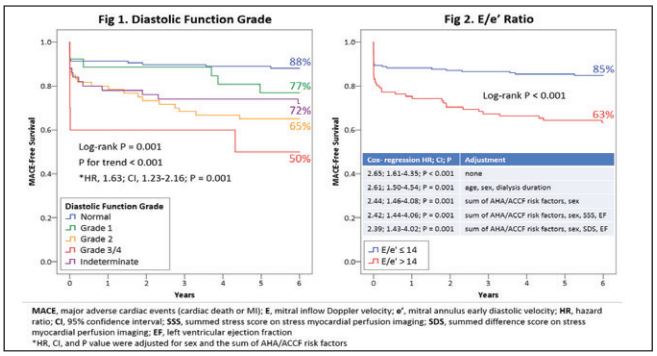
Background: Cardiac abnormalities on echocardiography are common in patients with end-stage renal disease and has been associated with an increased risk of cardiac events. The impact of pre-transplant diastolic dysfunction (DD) or high filling pressures on post-transplant outcome of renal transplant (RT) recipients is unknown. **Methods:** In a retrospective cohort of consecutive RT recipients, transthoracic echocardiograms were reviewed for the presence and grade of DD using the latest ASE recommendations for the evaluation of left ventricular DD by an observer blinded to other clinical, imaging, and outcome data. Clinical risk was determined using the sum of risk factors (range 0 - 8) set-forth by AHA/ACCF consensus statement on the assessment of kidney transplant candidates (age > 60 y, hypertension, diabetes, smoking, dyslipidemia, cardiovascular disease, dialysis > 1 y, left ventricular hypertrophy). Patients underwent stress myocardial perfusion imaging pre-transplant and were followed for major adverse cardiac events (MACE), defined as cardiac death and myocardial infarction up to 6 years post-transplant. Kaplan-Meier plots, log-rank test and cox-regression models were used in outcome analyses. **Results:** Among 297 patients analyzed (39% females, mean age 53 ± 12 y), 272 patients had some degree of DD (9%, grade 1; 20%, grade 2; 3%, grade 3 or 4) and 50 patients (17%) were classified as indeterminate. Among 281 patients with available E/e' ratio, 101 (36%) patients had elevated left ventricular filling pressures assessed by averaged septal and lateral E/e' > 14. A total of 68 MACEs were observed during a mean follow-up of 2.9 ± 1.9 y. There was a stepwise increase in MACE risk with increasing diastolic dysfunction grade, this association persisted after adjusting for sex and the sum of AHA/ACCF risk factors (Fig. 1). E/e' > 14 was associated with a significant increase in MACE risk, which remained significant after adjusting for age, sex, duration of hemodialysis, AHA/ACCF risk factors, stress perfusion imaging, and left ventricular ejection fraction (Fig 2). **Conclusion:** High filling pressure assessed by E/e' ratio and DD grade are independent predictors of MACE risk in RT recipients with a direct correlation between DD severity and MACE rates.



P1-196

Titin Truncation Position Determines Propensity for Dilated Cardiomyopathy, Abnormal Ventricular Relaxation and Late Diastolic Stiffness: An Echocardiographic Analysis of Four Zebrafish Models

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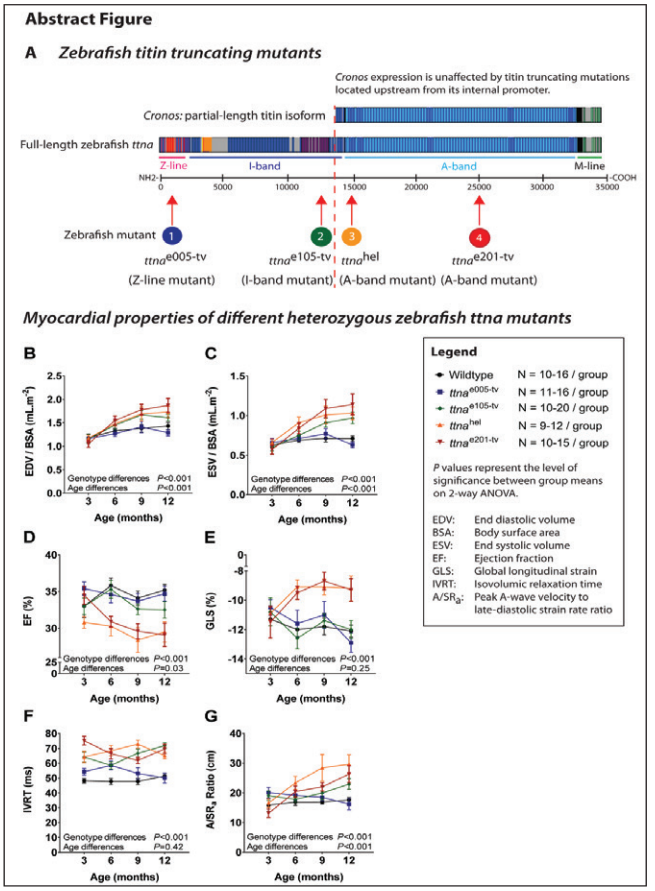
Background: Truncating variants of the titin gene (*TTN*tv) are associated with risk of dilated cardiomyopathy (DCM), but the prognostic implications for any individual heterozygous carrier remains unclear. It has been proposed that DCM is more likely if a *TTN*tv 1) is located in a highly utilized exon present in the majority of cardiac isoforms or 2) affects the titin A-band. We therefore studied adult zebrafish models of different titin truncations to evaluate mutation position effects on systolic and diastolic function *in-vivo*. **Methods:** Serial echocardiography was performed at 3, 6, 9 and 12 months on male heterozygotes and wildtype siblings (N=9-20/group) from four separate models of zebrafish titin (*ttna*) truncation (see **Panel A**). These mutations, all in highly utilized exons, included 1) *ttna*$^{e005\text{-}tv}$ in the Z-line; 2) *ttna*$^{e105\text{-}tv}$ in the distal I-band; 3) *ttna*^{hel} in the proximal A-band, and 4) *ttna*$^{e201\text{-}tv}$ in the mid A-band. The first two truncations were located upstream, while the latter two were downstream of the internal promoter for the C-terminus titin isoform, *Cronos*, in the distal I-band. **Results:** Heterozygous mutants differed in their propensity for chamber dilatation and contractile dysfunction. The two A-band mutants showed spontaneous ventricular dilatation (**Panels B-C**), reduced ejection fraction (**Panel D**) and reduced global longitudinal strain (**Panel E**). The I-band mutant had an intermediate phenotype consistent with *forme fruste* DCM. Abnormalities during early diastole (e.g. isovolumic relaxation time, **Panel F**) were present in A-band and I-band mutants. The late-diastolic peak A-wave velocity to late-diastolic strain rate ratio (A/SR_a, **Panel G**) was highest in A-band mutants, followed by the I-band mutant, consistent with mutation position dependent effects on late-diastolic ventricular stiffness. The Z-line mutant did not significantly differ from wildtypes in relation to the above parameters. **Conclusion:** Severity of the DCM phenotype varied according to mutation position in zebrafish titin truncation, with the effect greatest in A-band mutants. A novel finding is that titin truncating mutations also display evidence of impaired ventricular relaxation and compliance. This study has clinical significance regarding the implications for tolerance of mechanical stress in human carriers.



P1-197

Impact of Biventricular Imaging Markers on Outcomes in Non Compaction Cardiomyopathy: A Machine Learning Study

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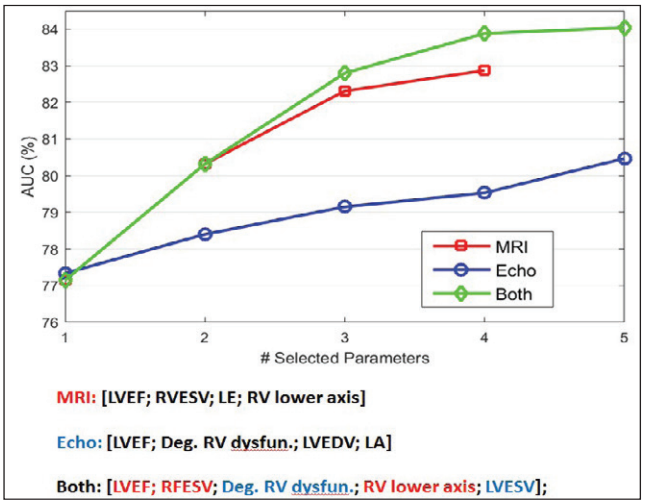
Aims: Left ventricular non-compaction cardiomyopathy (LVNC) is a genetic heart disease according American Heart Association, which main clinical manifestations are heart failure, arrhythmias and embolic events. Its prevalence is increasing due improvements in imaging cardiac methods, such as echocardiography (echo) and cardiac magnetic resonance imaging (CMRI). However, imaging parameters related to prognosis are poorly known. The goal of this study was to analyze a large set of echocardiographic and CMRI parameters using machine learning techniques, in order to find an association between these imaging markers and clinical outcome in a long-term follow-up of LVNC patients. **Methods:** Patients with LVNC diagnosed by echo and CMRI current criteria, from a tertiary center, were recruited and they were followed. Combined 'hard events' (death, cardiac transplantation, heart failure hospitalization, aborted sudden cardiac death, complex ventricular arrhythmias, and embolisms) were registered. CMRI and echocardiographic parameters were extracted by expert users and subsequently analyzed via a supervised machine learning methodology using 'cross-validation'. Ethical committee approved the protocol and all patients gave written informed consent. **Results:** One hundred and eight LVNC patients (38,3 ±15,5 years, 48% male) diagnosed by echo

and CMRI criteria were recruited for this study and were followed for 5,83 ± 3,9 years. Forty-seven (43,5%) patients presented at least one hard event. The best combination of imaging markers was left ventricular ejection fraction (CMRI), right ventricular end-systolic volume (CMRI), right ventricular systolic dysfunction (echo), right ventricular lower diameter (CMRI) and left ventricular end-systolic volume (echo), with an accuracy, sensitivity and specificity of 75%, 80%, 72%, respectively (Figure 1). **Conclusion:** The combination of echo and CMRI indices improved the stratification of the risk in LVNC patients. Also, our findings showed the importance of biventricular assessment to detect the severity of this cardiomyopathy.



P1-198

Pre-operative Pulmonary Artery Systolic Pressure by Echocardiography and Outcomes in Renal Transplant Recipients

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Background: The association between pulmonary hypertension and renal transplant outcomes has not been well studied. We evaluated the relationship between estimated pulmonary artery systolic pressure (PASP) by transthoracic echocardiogram (TTE) and outcomes in renal transplant recipients. **Methods:** This is a single-center retrospective study of 567 consecutive patients who have received renal transplant from January 2008 to December 2015. Total of 191 patients who have documented PASP estimated by TTE prior to renal transplantation were included in the study. Patients were divided in 2 groups: normal PASP was defined as <37 mmHg (n=141) and elevated PASP was ≥37 mmHg (n=50). Differences between the groups were analyzed using t-test, chi-square test and analysis of variance for mean values. We examined correlation of PASP and 1-year and 2-years renal function outcomes using multivariate, logistic regression analysis. **Results:** Mean age of the total cohort was 51.26±12.42, 36.13% female, 81.15% Caucasian, and 12.04% African American. There was no significant difference between the groups in age, gender, ethnicity and comorbidities. Patients with elevated PASP had higher proportion of left ventricular ejection fraction <50% (7% vs 3.5%, p=0.01). Elevated PASP group compared to normal PASP had higher 1-year post-transplant creatinine (1.44 mg/dL vs 1.23 mg/dL, p=0.01) and lower estimated glomerular filtration rate (eGFR) (55.22 mL/min/1.73m^2 vs 62.18 mL/min/1.73m^2, p=0.03). On both univariate and multivariate analyses elevated PASP was associated with higher 1-year post-transplant creatinine (regression coefficient 0.184, 95% CI 0.02-0.35, p=0.028) and lower eGFR (regression coefficient -8.297, 95%CI -14.99 to -1.61, p=0.015). Similarly, higher PASP was associated with lower eGFR at 2 years post-transplantation. **Conclusions:** Renal transplant recipients with elevated PASP on pre-operative TTE had lower eGFR at 1-year and 2 years post-transplant. Preoperative echocardiographic evaluation for pulmonary hypertension could be helpful in predicting probability of renal graft dysfunction.

	PASP < 37 mmHg (n=141)	PASP ≥ 37 mmHg (n=50)	p-value
Mean age ± SD	50.30±12.43	52.21±10.86	0.287
Male (%)	65.25	60.00	0.507
Caucasian (%)	81.56	80.00	
African American (%)	10.64	16.00	0.317
Type of transplant - Live (%)	19.86	14.00	0.358
LVEF			
<50%	3.55	7.00	**0.009**
≥50%	96.45	93.00	
Mean PASP (mmHg) ± SD	26.98 ±5.42	52.48±10.86	**<0.001**
Left ventricular hypertrophy (%)	24.11	28.00	0.586
Co-morbidities (%)			
prior myocardial infarction	8.51	8.00	0.911
Hypertension	85.82	80.00	0.332
Diabetes mellitus	28.37	30.00	0.827
Hypothyroidism	8.51	8.00	0.911
COPD	1.42	0.00	0.397
Smoking	29.79	16.00	0.057
ETOH use	15.60	8.00	0.178
Outcomes			
Creatinine at 1-year (mg/dL)	1.25	1.44	**0.017**
eGFR at 1-year (mL/min/1.73m^2)	60.13	52.26	**0.019**
Creatinine at 2-year (mg/dL)	1.31	1.43	0.095
eGFR at 2-year (mL/min/1.73m^2)	60.28	51.04	**0.006**
Hospital stay (days) ± SD	9.32±5.84	10.24±6.17	0.346

P1-199

Is There a Mortality Benefit in the Use of Intra-Aortic Balloon Pumps in Patients with Takotsubo Cardiomyopathy and Cardiogenic Shock

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Background: Takotsubo cardiomyopathy (TC) is a transient left ventricular ballooning that can lead to cardiogenic shock, which can be treated with an intra-aortic balloon pump (IABP). The purpose of this study is to determine the mortality benefit of an IABP in patients diagnosed with both TC and cardiogenic shock. **Methods:** We used the NIS database to identify all patients (1676) who were diagnosed with TC and cardiogenic shock from 2007 till 2014, using ICD-9 codes 429.83 and 785.51 respectively. We analyzed and compared the mortality between 451 patients who received an IABP (ICD-9 code 37.61) and 1225 patients who did not receive the IABP, to determine if the pump had a mortality benefit in any subset of patients with various baseline characteristics, from those included in the NIS database, as well as additional diagnoses including arrhythmias, psychiatric conditions, and septic shock, which were indicated as risk factors for TC in previous literature. **Results:** Of the 1676 patients, 1350 were female, and 326 were male ($p < 0.05$). The overall mortality was 21%, but was higher in males (27.3%) vs. females (19.3%) ($p = 0.002$) regardless of pump status. 451 patients received the pump (mortality 18%) and 1225 patients did not receive the pump (mortality 22%). The majority of patients diagnosed with TC and cardiogenic shock were Caucasian (1183, 70.5%), and some common underlying diagnoses included electrolytes abnormalities (64.1%), hypertension (49.6%), CHF (32.4%), hyperlipidemia (24.3%), atrial fibrillation (21.2%), septic shock (20.5%), diabetes (18.1%), depression (11.5%) and anxiety (9%). With a Chi-square analysis we found that patients with depression or anxiety, who received an IABP, showed mortality benefits, with p values of 0.05 and 0.04 respectively, when compared to patients who did not get a pump. Patients with atrial fibrillation who received an IABP had a mortality benefit with a p value of 0.06 (i.e. approaching significance) compared to those without the IABP. IABP use showed mortality benefits in other subsets of patients, but the p values were not significant. **Conclusion:** There are significantly more females with TC and cardiogenic shock than males, whereas the mortality is significantly higher in males regardless of pump status. We identified two patient groups (depression, anxiety) that showed statistically significant mortality benefits, and one (atrial fibrillation) with a mortality benefit approaching significance, with the use of an IABP for TC and cardiogenic shock.

P1-200

Arrhythmogenic Cardiomyopathy: Which Echocardiographic Parameters are Risk Factors for Malignant Arrhythmia?

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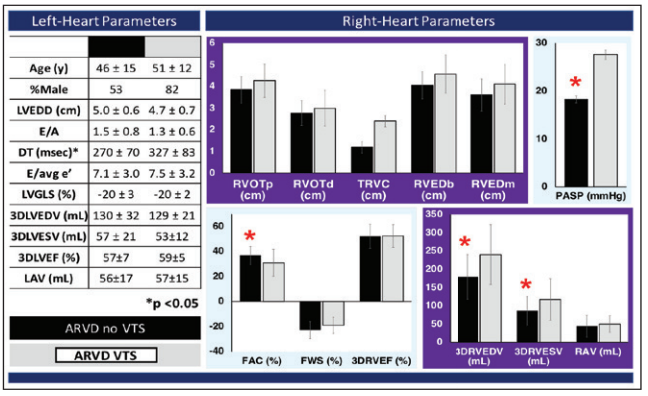
Background: Arrhythmogenic cardiomyopathy (ARVC) is a progressive disease characterized by fibrous/fatty replacement of the myocardium and sudden death caused by ventricular arrhythmias. Although little is known about which 2D transthoracic echocardiography (TTE) parameters portend a worse outcome, this modality is often used to follow disease progression. Additionally, the use of 3D TTE in this context has

not been explored. Accordingly, we prospectively acquired 2D and 3D TTE studies in ARVC patients at varying stages of disease to determine whether any echocardiographic parameters are associated with a history of ventricular tachycardia or syncope (VTS). **Methods:** 54 patients (47±14y; 61%male) with ARVC (11 with VTS; 43 without) were prospectively enrolled. 2D end-diastolic dimensions of the left (LVEDD) and right (basal, RVEDb and mid RVEDm) ventricles, proximal and distal right ventricular (RV) outflow tract (RVOTp, RVOTd), 2D right and left atrial volumes (RAV, LAV), 2D diastolic function parameters including (mitral inflow E/A, deceleration time, DT and the ratio between E and the mean lateral and medial mitral annular e'), RV fractional area change (FAC), left ventricular (LV) global longitudinal strain (GLS), RV free-wall strain (FWS), pulmonary artery systolic pressure (PASP) and tricuspid regurgitation vena contracta width (TRVC) were measured. 3D full-volume datasets of the LV and RV were analyzed (Tomtec) to obtain end-diastolic and end-systolic volumes (EDV, ESV) and EF. ARVC patients with and without VTS were compared using unpaired t-test. **Results:** Age was not significantly different between ARVC groups. There were more men in the ARVC with VTS group. Patients with ARVC with VTS had longer DT, lower FAC, higher PASP and larger 3D RV volumes than the group without VTS. 2D RV basal and mid-ventricular dimensions as well as RVOTp and RVOTd dimensions tended to be larger in the ARVC with VT group (**Figure**). In contrast, no intergroup differences were noted in atrial and LV parameters. **Conclusions:** In patients with ARVC, larger RV size with higher PASP is associated with increased risk for VT and syncope. Worsening RV parameters should be interpreted as an indicator for increased VTS risk.



P1-201

Identification of Patients with Chagas Disease at Risk of Worsening Cardiomyopathy Using 2-D Speckle Tracking Strain

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Background: Chagas disease is a major cause of morbidity in Latin America where it affects approximately 8 million people, with highest prevalence in Bolivia. An estimated 20-30% of those infected go on to develop Chagas cardiomyopathy (CC) and clinical heart failure. There is currently a lack of reliable predictors of CC, hindering early identification and treatment of patients at highest risk of progression. **Methods:** This prospective observational study was conducted at the Hospital San Juan de Dios, the largest public hospital of the city of Santa Cruz, Cordilleras Province of Bolivia. Between 2016-2017, participants underwent a focused history and physical examination, a 12-lead ECG and a 2D echocardiogram at baseline and at one-year follow-up. Thirty-one patients who were classified as Stage B by their characteristic ECG abnormalities but without structural changes by echocardiogram at baseline were selected from the overall cohort. They were considered to have progressed if they were Stage C or D as evidenced by moderate to severe systolic dysfunction at their subsequent visit. Echocardiograms from both visits were analyzed offline for peak averaged and regional left ventricular global longitudinal systolic strain (GLS) using TomTec Image-Arena software. Measurements were compared between patients who progressed and did not progress by two-sample t-test, as well as the change over time. **Results:** Of the 31 patients, 8 had progressed to Stage C or D at follow-up. Mean age among progressed was 60.5 years and 62.5% female, compared with 54.1 years and 78.3% female among non-progressed. At baseline, mean LVEF was lower and peak GLS was less negative among those who progressed versus those who did not (see table). These differences were similar at the follow-up visit. **Conclusion:** Mild abnormalities in GLS and LVEF are detectable in asymptomatic patients with Chagas disease who go on to develop symptoms or clinical heart failure. Screening this at-risk population for these changes may provide an opportunity for earlier treatment.

	Not progressed (n=23)	Progressed (n=8)	p-value*
Age, years	54.1 +/- 14.7	60.5 +/- 8.7	0.260
Female, %	78.3	62.5	0.380
BMI, kg/m^2	29.2 +/- 6.0	31.0 +/- 4.6	0.461
Baseline Echo			
LVEF, %	58.6 +/- 9.3	48.3 +/- 9.8	0.017
Avg peak LV GLS, %	-23.0 +/- 3.3	-18.0 +/- 4.5	0.003
Follow-up Echo			
LVEF, %	60.9 +/- 6.4	47.6 +/- 8.5	<0.001
Avg peak LV GLS, %	-23.6 +/- 2.5	-18.4 +/- 3.5	<0.001
Baseline to F/U α			
LVEF, %	2.3 +/- 9.3	-0.3 +/- 5.9	0.501
Avg peak LV GLS, %	-0.4 +/- 2.7	-0.5 +/- 1.5	0.910
Days between	360 +/- 57	395 +/- 71	0.179
* t-test for continuous and χ^2 test for dichotomous variables.			

P1-202

Echo Combined with Conventional Chest CT Predicts MACE in Septic Patients Better than Echo or CT Alone

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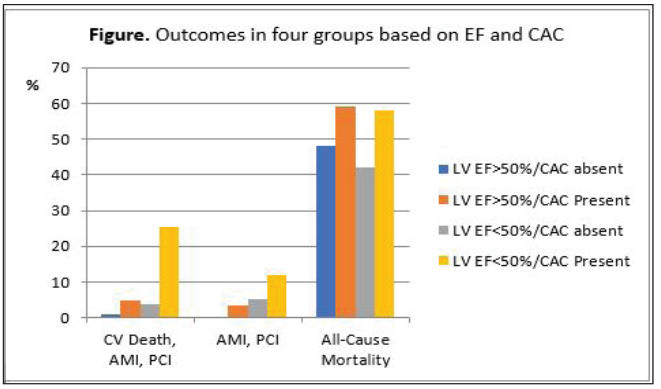
Background: Sepsis is a common clinical condition with poor outcomes, and myocardial dysfunction has had limited predictive value for all-cause mortality on previous studies. However, there is limited research on risk stratification of septic patients for MACE (up to 25-30% in 1 year). This study proposes the use of left ventricular ejection fraction (EF) on echocardiogram and coronary artery calcification (CAC) on non-gated CT scans to identify septic patients at highest risk for MACE. **Methods:** This was a retrospective cohort study of adult septic patients at a tertiary care center with detectable troponin levels, non-gated CT scans that visualized the coronaries, and an echocardiogram. Patients with a recent cardiac intervention were excluded. EF ≥ 50% was considered normal. CAC was identified as present or absent on CT. Patients were stratified into 4 groups: normal EF/CAC absent, normal EF/CAC present, low EF/CAC absent, low EF/CAC present. The primary endpoint was a composite of CV death, acute myocardial infarction (AMI) or percutaneous coronary intervention (PCI) at 1 year. The secondary endpoints were all-cause mortality at 1 year, and AMI or PCI at 1 year. Fisher's exact test and Chi^2 were used for analysis. **Results:** 307 septic patients (60 +/- 14 years old, 54% male) were included in evaluation of the primary outcome. Overall, 8% (n=24) met the primary endpoint at 1 year, and only 1 patient was in the normal EF/CAC absent (n=89) group. Using normal EF/CAC absent as a control, patients with a low EF/CAC present (n=59) had the highest primary endpoint (22%, p<0.001) as well as higher rates of AMI/PCI (12% vs 0%, p<0.05), but no increase in all-cause mortality at 1 year (58% vs 48%, p=NS). **Conclusion:** EF on echocardiogram provides a powerful risk stratification tool for predicting CV events in septic patients. With the addition of CAC on non-gated CT scans, physicians have a novel stratification schema to triage at risk patients who may benefit from additional testing or therapeutic interventions.



P1-203

Impact of the Introduction of the 2016 ASE/EACVI Guidelines on the Reporting of Diastolic Function on Echocardiography

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Background: In 2016, the American Society of Echocardiography updated its 2009 diastolic function guidelines to simplify the approach to diastolic function assessment and thus increase its utility in daily clinical practice. There is sparse data on the impact of the guideline update on the reporting of diastolic function in the literature. Hence, we conducted this study to see if this novel approach to diastolic function determination influences the echocardiography reporting practice at our institution. **Methods:** We

retrospectively reviewed all adult echocardiographic studies performed at our institution between July 2015 to March 2017, divided into two 9-month time periods before and after the guideline update (July 2015-March 2016; and July 2016 to March 2017). We excluded studies performed on patients with depressed LVEF or any of the conditions that may make diastolic function assessment challenging. We identified data for each of the periods and assessed what proportion of the reports had any statement on diastolic function assessment. We subsequently determined the accuracy of such reporting according to the guidelines in place at each period. Statistical analysis was performed using SPSS version 24. **Results:** 5,645 echocardiographic studies were included in this analysis, divided into the pre-guideline update cohort (2,648 studies) and the post-guideline update cohort (2,997 studies). The number of studies that could not be adequately classified using the available parameters when guidelines were applied strictly reduced from 79.2% using the 2009 guidelines to 2.7% with the 2016 guidelines. The reporting of diastolic function by our echocardiography readers improved from 82.1% pre-update to 88.9% post-update ($p < 0.001$). There was also an improvement in accurate classification of normal and abnormal diastolic function from 22.7% and 59.4% pre-update to 42.9% and 37.0% post-update, closer to the gold standard by ASE definition of 60.1% and 19.8%, respectively ($p < 0.001$). In addition, there was a statistically significant improvement in the accuracy of reporting of diastolic dysfunction grade from 16.6% to 39.4% pre-and post-update, respectively ($p < 0.001$). **Conclusions:** The new diastolic function guidelines allow for easier and more accurate classification of diastolic function using fewer parameters. The proportion of studies for which diastolic function could not be classified reduced significantly. There was a statistically significant increase in reporting of diastolic function by our echocardiographers and in the accuracy of diastolic function classification.

P1-204

Right Ventricular Strain is an Independent Predictor of Interstitial Lung Disease in Systemic Sclerosis

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Background: Interstitial lung disease (ILD) is the leading cause of death in systemic sclerosis (SSc). The right ventricular (RV) strain assessment in SSc is useful for the detection of RV dysfunction, but little is known whether RV strain can diagnostic accuracy for detecting ILD. We aimed to evaluate the relation between ILD AND RV function assessed RV strain. **Methods:** We retrospectively reviewed the records of 173 SSc patients (62±11 years; 153 females) who underwent echocardiography with speckle tracking strain. We measured left ventricular (LV) global strain (LVGLS), RVGLS, RV free wall strain, tricuspid annual plane systolic excursion (TAPSE) AND fractional area change (FAC). **Results:** Chest CT revealed 73 SSc patients with ILD, who had higher prevalence of diffuse cutaneous SSc AND greater skin score than those without. There were no significant differences in age, gender, disease duration, AND LVEF between the groups. RV GLS AND free wall strain were lower in patients with ILD than in without although TAPSE AND FAC were similar between the groups. Furthermore, RV global strain≦18.2% predicted ILD with sensitivity 68%, specificity of 68% (AUC=0.70, $p<0.001$), AND so RV free wall strain≦18.8% did with sensitivity 60%, specificity of 78% (AUC=0.71, $p<0.001$). On multivariable logistic regression analysis (Table), RV strain (global AND free wall) were independent (both $p=0.001$) AND incremental predictors (both $p<0.001$) for SSc-ILD when added to the model with age, gender, diffuse cutaneous SSc, skin core, RVSP AND TAPSE. **Conclusion:** RV strains were independent predictors for predicting interstitial lung disease in patient with SSc.

Table. Univariable and Multivariable Logistic Regression Analyses for Associations with Interstitial Lung Disease

	Univariable	Multivariable	
		Model 1	Model 2
	OR (95% CI)	OR (95% CI)	OR (95% CI)
RV global strain,%	0.87(0.82 - 0.93) *	085(0.77 - 0.94) *	-
RV free wall strain, %	0.89(0.85 - 0.95) *	-	089(0.83 - 0.96) *
Age, years	1.00(0.98 - 1.03)	1.01(0.96 - 1.05)	1.01(0.97 - 1.06)
gender	2.28(0.93 - 5.60)	0.56(0.13 - 2.46)	1.01(0.29 - 3.56)
Diffuse cutaneous SSc	6.64(3.26 - 13.5) *	10.2(2.99 - 34.7) *	13.7(4.39 - 42.9) *
Skin score	1.07(1.01 - 1.12) *	0.99(0.91 - 1.07)	0.99(0.90 - 1.07)
RVSP, mmHg	1.02(0.99 - 1.05)	0.99(0.93 - 1.05)	0.99(0.94 - 1.06)
TAPSE, mm	0.94(0.86 - 1.03)	0.94(0.83 - 1.07)	0.94(0.82 - 1.07)

*p<0.05

P1-205

Global Longitudinal Strain is Preserved in Pregnant Women With Advanced Maternal Age: a Speckle Tracking Echocardiography Study

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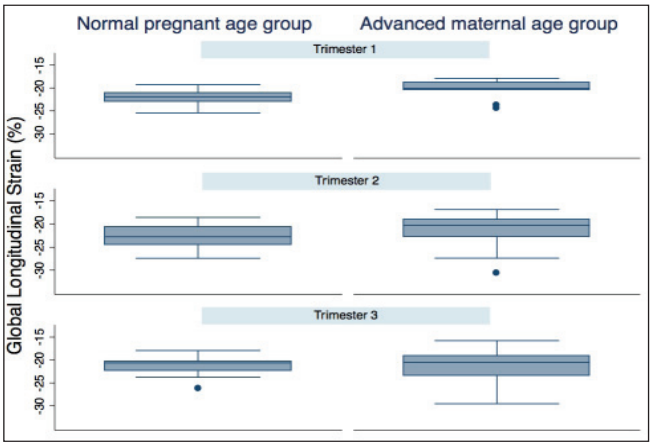
Background: Speckle tracking echocardiography (STE) is a sensitive tool to evaluate subtle myocardial deformation. No previous study has examined myocardial alterations by STE among pregnant women with advanced maternal age (AMA). We aimed to determine if pregnant women of AMA had myocardial changes detectable by STE that indicate subclinical myocardial dysfunction. **Methods:** We included women who visited the prenatal clinic at our institution from 2008 to 2015 and had a transthoracic echocardiogram during pregnancy. The AMA group was defined as women of maternal age ≥35 years and the control group consisted of women of maternal ages 18-34 years. Women with pre-existing diagnoses of any cardiac conditions were excluded. Global longitudinal, circumferential, radial strain and strain rate measurements by STE were summarized as means and standard deviations. Comparison of strain variables was performed using the Student's t-test or one-way analysis of variance method. **Results:** We analyzed 103 pregnant women, including 54 women in AMA group and 49 women in normal pregnant age group. Mean age of AMA group was 38.8 (± 3.2) years. Mean age of the control group was 27.5 (± 4.5) years. Left ventricular ejection fraction was similar in the AMA and control groups (64.2% ± 4.5% versus 63.9% ± 4.4%, P=0.693). Mean global longitudinal strain of AMA group was -21.9% ± 3.5%, similar to that of normal pregnant age group (-22.1% ± 2.1%, P=0.724). Mean radial strain of AMA group (24.8% ±18.0%) was significantly lower than that of normal pregnant age group (36.4% ± 22.5%, P=0.005). Circumferential strain was significantly higher in patients with AMA (-26.9% ± 7.1% versus -23.8% ± 4.6%, P=0.011). There was no significant difference in strain or strain rate by trimesters and study groups (Figure 1). **Conclusion:** Global longitudinal strain was preserved in pregnant women with AMA in our cohort, whereas the circumferential strain and radial strain of AMA group were significantly different from those of normal pregnant age group. Further studies to explore myocardial deformation in pregnant women with AMA are warranted.

Figure 1. Global Longitudinal Strain of Normal Pregnant Age Group and Advanced Maternal Age Group by Trimesters.



P1-206

In Fetuses with Congenital Lung Masses, Decreased Atrioventricular Valve and Ventricular Dimensions are Associated with Lesion Size and Clinical Outcome

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Background: In fetuses with congenital lung masses, congenital pulmonary airway malformation volume ratio (CVR) and lesion volume are associated with increased risk of neonatal respiratory distress (RD). Little is known about the association between cardiac dimensions and lesion size or clinical outcome. **Methods:** Cases were identified from the Fetal and Pregnancy Health database between 2009 and 2016. Blinded observers measured atrioventricular valve annulus dimensions (AVVz) and ventricular widths (VWz) converted into Z-scores and estimated ratio of aortic to total cardiac output (AoCO). Other fetal data obtained include: lesion side, lesion CVR on ultrasound and lesion volume on MRI. Neonatal respiratory distress (RD) was defined as: intubation, ECMO use or surgical intervention prior to discharge. **Results:** 49 fetuses which had echocardiographic, ultrasound, and outcome data available comprised the study cohort.

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Of these, 45 (92%) had fetal MRI performed within 6 weeks of the echocardiogram. Mean gestational age at echocardiogram, ultrasound and MRI were 25.5±4.7, 25.3±5.9 and 24.7±5.8 weeks, respectively. CVR correlated with ipsilateral AVVz (R_S=-0.58, p<0.001), ipsilateral VWz (-0.68, p<0.001) and AoCO (R_S= -0.29, p=0.040). Lesion volume correlated with ipsilateral AVVz (R_S= -0.43, p=0.008), and ipsilateral VW (R_S= -0.52, p=0.001), but not AoCO (R_S= -0.20, p=0.252). In left-sided lesions, CVR was associated with AVVz, VWz and AoCO (R_S= -0.69, -0.86, -0.46 and p<0.001, <0.001, and = 0.010 respectively). In right-sided lesions, AVVs, VWz, and AoCO did not correlate with CVR. Mean AVVz and VWz were below expected for gestational age (table 1). In the entire cohort and in left-sided lesions specifically, lower AVVz and AoCO were associated with RD, while the association between RD and VWz approached significance. In right-sided lesions, there was no significant association between RD and AVVz, VWz or AoCO. Higher CVR was associated with RD in left- but not right-sided lesions. There was no association with lesion side and RD. No fetus had structural heart disease. **Conclusions:** In fetuses with left-sided lung masses, smaller ipsilateral heart structures correlate with lesion size and neonatal RD. Compression of left-sided cardiac structures may contribute to neonatal RD in this population.

Table 1

	Entire cohort (N=49)			Left-sided lesion (N=28)			Right sided lesion (N=21)		
	Resp Distress (N=19)	No Resp Distress (N=30)	Overall	Resp Distress (N=11)	No Resp Distress (N=17)	Overall	Resp Distress (N=8)	No Resp Distress (N=13)	Overall
Ipsilateral AVV z-score	-2.08 ± 1.46	-0.86 ± 1.08	-1.34 ± 1.33	-2.65 ± 1.49	-1.08 ± 0.98	-1.67 ± 1.36	-1.17 ± 1.07	-0.56 ± 1.17	-0.75 ± 1.14
	p=0.002			p=0.002			p=0.298		
Ipsilateral VW z-score	-1.95 ± 1.43	-1.31 ± 1.25	-1.52 ± 1.35	-2.54 ± 1.07	-1.08 ± 0.98	-1.92 ± 1.17	-1.02 ± 1.77	-0.79 ± 1.37	-0.87 ± 1.46
	p=0.110			p=0.051			p=0.764		
Ratio of aortic to total cardiac output	0.29 ± 0.08	0.36 ± 0.10	0.34 ± 0.10	0.27 ± 0.07	0.33 ± 0.08	0.32 ± 8.6	0.30 ± 0.08	0.40 ± 0.11	0.37 ± 0.11
	p=0.012			p=0.083			p=0.070		
Congenital pulmonary airway malformation volume ratio (CVR)*	0.96 (0.41, 2.0)	0.48 (0.28, 0.97)	0.60 (0.29, 1.15)	1.20 (0.57, 2.55)	0.41 (0.27, 0.98)	0.60 (0.30, 1.20)	0.40 (0.21, 0.85)	0.54 (0.32, 1.02)	0.54 (0.26, 0.92)
	p=0.034			p=0.003			p=0.360		

*Reported as median (IQR). All other data reported as mean ± SD

P1-207

Comparison of Left Ventricular Energy Loss between Patients with Idiopathic and Secondary Cardiac Hypertrophy

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Aims: Patients with hypertrophic cardiomyopathy (HCM) and hypertension (HBP) share similar echocardiographic features but have different afterload status. The current study aims to evaluate left ventricular energy loss (LVEL) in patients with HCM and HBP using vector flow map (VFM). **Methods:** Twenty-five HCM patients (17 males, 8 females, and 55.24±14.53yrs), 21 HBP patients (19 males, 2 females, and 54.44±14.36yrs) and 36 healthy subjects (15males, 21 females, and 27.52±3.65yrs) were enrolled as HCM group, HBP group and control group. HCM group,and HBP group have similar LV mass. All the subjects have normal left ventricular ejection fraction(LVEF). Color Doppler imaging of apical four-chamber view, two-chamber view and long-axis view loops were recorded for VFM analysis. According to the opening and closing of the aortic valve and mitral valve, isovolumic contraction (IVC), isovolumic relaxation (IVR), ejection period (EP) and filling period (FP) were determined. Total LVEL during IVC, IVR, EP and FP as well as peak LVEL during IVC and IVR were quantified. **Results:** 1.Compared to the control group, peak IVR-LVEL was decreased in both patient groups, and HCM group was the lowest (p<0.05). EP-LVEL, and peak IVC-LVEL were increased, while FP- LVEL was decreased in HCM group (all p<0.05); IVC-LVEL, peak IVC-LVEL , andEP-LVEL were increased in HBP group (all p<0.05). 2.Compared with HCM group, HBP group has the higher IVC- LVEL, peak IVR-LVEL, IVR-LVEL andFP-LVEL (all p<0.05). **Conclusions:** Patients with cardiac hypertrophy and normal LVEF, have increased systolic LVEL and reduced diastolicLVEL. HBP patients have more energy loss than HCM patients. LVEL might be a sensitive and valuable parameter to distinguish cardiac hypertrophy of different etiology.

P1-208

Disease Stage-Dependent Changes of Cardiac Contractile Performance in Patients with Fabry Cardiomyopathy

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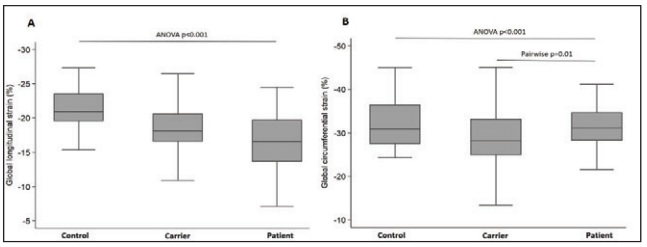
Background: Fabry cardiomyopathy (FC) is characterized by progressive left ventricular hypertrophy, which leads to systolic and diastolic dysfunction. Here we evaluated disease-stage dependent changes in myocardial contractile performance. **Methods:** Patients carrying Fabry mutated gene were recruited from 2007 to 2016. The study comprised 117 asymptomatic mutation carriers, 57 FC patients on enzyme replacement therapy and 33 healthy individuals. Standard transthoracic echocardiography, deformation analysis and hemodynamic study were performed. **Results:** A total of 207 patients (mean age 49 ± 16 years, 45% men) were included. Patients with FC were older, with a higher proportion of male sex. They also had more comorbidities and higher wall thickness. Patients with FC had the worst diastolic function, as evidenced by the largest left atrium, lowest E/A and highest E/e' ratio. The left ventricular ejection fraction were similar among three groups, but FC patients had higher LV end-diastolic volume as well as stroke volume. Progressive deterioration of global longitudinal strain (GLS) was found in carrier and in FC patients (control vs. carrier vs. patient = -21.7 ± 4.1 vs. -18.4 ± 3.6 vs. -16.3 ± 4.2, p<0.001) (Figure A). A positive correlation was observed between LV mass and GLS (r=0.499, p=0.01). On the contrary, the global circumferential strain (GCS) slightly declined in carrier, but a high normal value of GCS was found in FC patients (p<0.001) (Figure B). **Conclusion:** Progressive deterioration of GLS was found in patients with Fabry cardiomyopathy, even in early asymptomatic stage. The increased LV mass was positively correlated with deterioration of GLS. On the contrary, the GCS remained the same or slightly improved in order to maintain stroke volume.



P1-209

Comparison of Global and Regional Myocardial Strains in Patients with Heart Failure with a Preserved Ejection Fraction vs Hypertension vs Age-Matched Control

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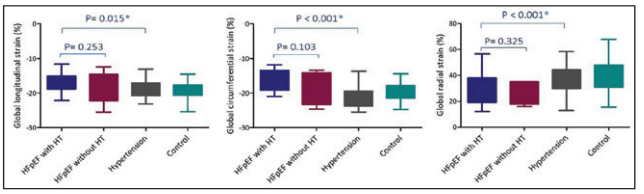
Background: With an increasing clinical importance of the treatment of the heart failure (HF) with preserved ejection fraction (HFpEF), it is important to be certain of the diagnosis of HF. We investigated global and regional left ventricular (LV) strains using echocardiography speckle tracking in patients with HFpEF and compared those parameters with that of patients with hypertension and normal subjects. **Methods:** Peak longitudinal, circumferential and radial strains were assessed globally and regionally for each study groups with two dimensional echocardiography using speckle-tracking. Diastolic strain rate was also determined. **Results:** There were fifty patients in HFpEF group, fifty-six patients in hypertension group and forty-six age-matched normal subjects. In patients with HFpEF, global peak longitudinal, circumferential and radial strain and strain rate were reduced compared to both hypertension patients and normal controls (-15.5±5.3 vs -17.7±3.1 and -19.9±2.0; -9.7±2.2 vs -19.3±3.1 and -20.5±3.3; 17.7±8.2 vs 38.4±12.4 and 43.6±11.9, respectively, P <0.001, for all). Furthermore, segmental peak longitudinal, circumferential and radial strain and strain rate were significantly lower in HFpEF group compared to both hypertension patients and normal controls, in all segments except in inferoseptal and inferolateral apical segments. In addition, global and segmental peak strain and strain rate were significantly higher in hypertension patients compared to normal subjects. **Conclusions:** In the speckle tracking echocardiography, impaired peak global strain and homogeneously reduced segmental strain was observed in HFpEF patients compared to the hypertension patients and normal subjects in decreasing order. This can provide early information on the initiation of LV deformation (of HFpEF) in patients with hypertension or normal subjects.



P1-210

Characterization of Left Ventricular Diastolic Function Difference in Patients with Exercise-induced Pulmonary Hypertension due to Heart Failure with Preserved Ejection Fraction vs Exercise-induced Pulmonary Arterial Hypertension

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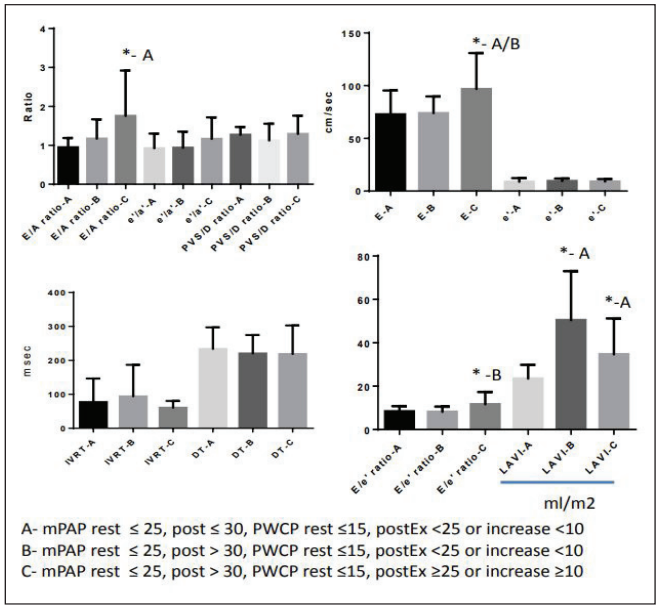
Background: Pulmonary hypertension (PH) is noted in Heart Failure with Preserved Ejection Fraction (HFpEF). Normal pulmonary capillary wedge pressure (PCWP) or left ventricular (LV) end-diastolic pressure at rest does not rule out HFpEF in well-diuresed patients; thus making early diagnosis difficult. Exercise right heart cath (Ex-RHC) can

help differentiating exercise-induced HFpEF from exercise-induced pulmonary arterial hypertension (PAH). The treatment and prognosis of patients with PAH or HFpEF-PH differ greatly. The aim of this study is to identify LV diastolic function Echo parameter(s) that correlate(s) with early HFpEF-PH. **Methods:** This is a retrospective study reviewing Echoes of patients who underwent Ex-RHC between 2014-2016. 125 patients who had resting Echoes around the time of Ex-RHC were identified, and 53 had normal PA pressure (mPAP ≤ 25 mmHg) at rest. Patients in the following three groups were analyzed: **A**-normal with no exercise-induced PH or HFpEF(postEx mPAP ≤ 30, PCWP ≤15, postEx PCWP< 25); **B**- exercise-induced PAH (postEx mPAP>30, PCWP ≤15, postEx PCWP< 25); **C**- exercise-induced HFpEF (postEx mPAP>30, PCWP <15, postEx PCWP≥ 25). Other groups had 0 or 1 patients, and were not analyzed. Echo diastolic parameters measured included E and e' velocity, E/A, e'/a' and E/e' ratio, isovolumic relaxation time (IVRT), pulmonary vein S/D ratio, left atrial volume index (LAVI). Data were analyzed using one-way ANOVA with Newman-Keuls post-test. **Results:** Among the 3 groups analyzed, the E velocity (96.8± 9.1 cm/s), E/A ratio (1.75±0.32), and E/e' ratio (11.6 ± 1.52) were significantly elevated in group **C** (HFpEF-PH, n=15) compared to groups **A** (normal, n=13) and **B** (Exercise-induced PAH, n=23). The LAVI in group **B** and **C** (50.5 ± 4.9, 34.7± 4.4 ml/m2) was increased and larger than in group **A**. The rest of the parameters were not statistically different among the 3 groups. No patients in the groups without exercise-induced PH but with HFpEF at rest or postEx were identified. **Conclusion:** This study suggests that in patients with normal resting PA pressure and exercise-induced HFpEF, LV diastolic function at rest may demonstrate early changes, including increased E velocity, E/A and E/e' ratio, and LAVI. This finding could help enable early identification and treatment of patients with occult HFpEF.



P1-211

Incidence and Characteristics of Pericardial Complications after Transcatheter Aortic Valve Replacement Compared with Surgical Aortic Valve Replacement

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Backgrounds: Pericardial problems are common after open heart valve surgery mainly related to an inflammatory process of pericardium. Since transcatheter aortic valve replacement (TAVR) does not open pericardium, it has theoretical advantages in terms of pericardial complications (PC) such as pericardial effusion and postoperative constriction compared with surgical aortic valve replacement (SAVR). On the other hand, acute pericardial hemorrhages sometimes occur during TAVR. In this study, we sought to identify incidence, timing of occurrence, and characteristics of PCs after TAVR and SAVR. **Methods:** A total of 240 patients who underwent TAVR (n=91) or SAVR (n=149) without any concomitant surgeries from Jan 2012 to Nov 2016 were analyzed. PCs were defined as pericardial hemorrhage, pericardial effusion larger than moderate degree and significant constrictive physiology on 2D and Doppler echocardiography. PCs were classified into three subgroups based on the occurrence timing after the procedure [acute PC (during the first 48 hours), subacute PC (48 hours~2 weeks), and chronic PC (2 weeks~6-months)]. **Results:** PCs were more common in SAVR than TAVR [76 (51.2%) vs. 9 (10.3%), p<0.001]. Acute PCs mainly due to pericardial hemorrhages tended to be lower in SAVR than TAVR (1(1.0%) vs. 6 (6.6 %), p=0.013). As a result of its intrinsic nature of SAVR, subacute and chronic PCs mainly due to effusive constriction were higher in SAVR than TAVR [73 (73%) vs. 4 (30%), p<0.001; 26 (26%) vs. 3 (3.3%), p=0.003, respectively]. Significant constrictive physiology after SAVR disappeared in a half of cases at 12 months after the surgery, reflecting its transient nature. The average of serum C - reactive protein after SAVR was higher than that after TAVR (130 ± 52 vs. 78 ± 49 mg/L, p<0.001), suggestive of robust inflammatory process in SAVR. The average of serum C - reactive protein after SAVR with PC was slightly higher than that that after TAVR with PC, but they are not significant different (124 ± 47 vs. 100 ± 49 mg/L, p=0.344). **Conclusions:** Incidence, timing of occurrence and characteristics of PCs were different after SAVR and TAVR. Understanding for these differences and pathophysiologic mechanisms of PCs after two procedures might improve patients' care with appropriate evaluation and diagnosis of PCs. Further studies are warranted to investigate the clinical outcomes related with PCs.

P1-212

Pericardial Effusion: A Reliable Imaging Indicator of Underlying Inflammation in Recurrent Pericarditis

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Background: Pericardial effusion (Peff) diagnosed on transthoracic echocardiography in acute pericarditis is known to be associated with adverse clinical outcomes. However, there is limited data on association of Peff with recurrent pericarditis (RP) from an outpatient database. Hence, we hypothesized that the presence of Peff is associated with worse outcomes in RP. **Methods:** We identified consecutive RP patients who were treated medically from 01/01/2007 untill 12/31/2016. Clinical variables, laboratory markers such as Westergren Sedimentation Rate (WSR); ultra-sensitive C-reactive protein (usCRP), clinical recurrences and transthoracic echocardiographic findings were recorded. Study population was divided into two groups: group A with Peff and group B without Peff. Primary outcome was chest pain and fever at time of echocardiogram. **Results:** 198 patients with total of 905 clinic visits (female 52%; mean age 46±14years) were included. During median follow-up period of 3.5 years (interquartile range 2.2 to 5.18 years), 88 (44%) patients had pericardial effusion and 9 (5%) had constrictive physiology at the initial visit. 51 (58%) patients had trivial Peff, 27 (31%) had small and 10 (11%) had moderate Peff. Large Peff or cardiac tamponade was not detected in any patient. 42 (21%) and 21 (14%) had prior pericardial window and pericardiocentesis respectively. Presence of pericardial effusion showed statistically significant association with chest pain (p=0.038) and fever (p=0.0117) at time of presentation. Pericardial rub (p=0.003), usCRP (p<0.05), WSR (p=0.0085) and prior episodes of pericarditis (p=0.005) also showed significant association. However, Peff was not associated with total number of recurrences during the treatment period (p=0.36) (see Table 1). **Conclusion:** Our study is the first to report the association of Peff diagnosed on echocardiography with clinical symptoms and markers of ongoing inflammation in patients with RP. Hence, presence of Peff in RP should prompt intensive guideline directed medical therapy under expert care to prevent ongoing recurrences.

Variable	Group A (n=88)	Group B (n=110)	p-value
usCRP (mg/L)	14.7 (0.8-16)	3.425 (0.5-4)	<0.05
CRP (mg/dl)	2.125 (0.55-3)	0.325 (0.1-0.4)	<0.05
WSR (mm/hr)	19.50 (4-24)	6.75 (3-10)	0.0085
Prior episodes of pericarditis	5.8±8.2	6±7	0.005
Total number of recurrences till last clinic visit	10.3±14	9.3±10	0.363
Heart Rate (bpm)	80±16	74±12	<0.05
Systolic Blood Pressure (mmHg)	123±17	118±13	<0.05
Pericardial / Pleuritic Chest Pain	63 (72%)	64 (58%)	0.038
Fever	5 (6%)	0 (0%)	0.0117
Pericardial Rub	1 (0.01%)	1 (0.01%)	0.003

P1-213

Left Ventricular Systolic Dysfunction following Acute Neurological Events: Beyond Takotsubo Cardiomyopathy

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Background: The development of Takotsubo cardiomyopathy (CM) in the setting of acute cerebrovascular events (ACE), such as stroke and intracerebral hemorrhage, is a well-documented phenomenon reportedly occurring in approximately 1% of patients. Neurogenic stunned myocardium in ACE has been described as a similar phenomenon with different patterns of myocardial involvement compared with Takotsubo CM variants. However, the frequencies of neurogenic stunned myocardium and Takotsubo CM remain poorly defined. In this study, we evaluated the frequency of left ventricular (LV) systolic dysfunction in the setting of ACE. **Methods:** Transthoracic echocardiograms (TTE) performed between May to October 2017 as part of a workup for stroke or intracerebral hemorrhage were retrospectively reviewed. Patients without CT or MRI evidence of an ACE, *i.e.* those with transient ischemic attacks, were excluded. Inclusion criteria were CT or MRI evidence of ACE and TTE performed during admission. The follow-up period

extended between four to nine months from ACE. In total, 120 patients met inclusion criteria. **Results:** 48% of patients were female. 18 patients (15%) had echocardiographic evidence of LV systolic dysfunction. Of these, eight patients (7%) developed transient LV systolic dysfunction followed by documentation of complete resolution. Of these, two had apical ballooning syndrome, one had mid-ventricular CM, one had global hypokinesis, and four had regional wall motion abnormalities (WMA) not matching common Takotsubo CM variants. For these eight patients, mean EF at time of ACE was 48±14% which improved to 57±4% on repeat TTE. None of them developed acute heart failure. All were discharged with a beta blocker, but only three were started on an angiotensin converting enzyme inhibitor. The 10 additional patients (8%) identified as having echocardiographic evidence of LV systolic dysfunction lacked follow-up TTE after discharge. **Conclusions:** The observed frequency of LV systolic dysfunction in the setting of ACE is much higher than what has previously been reported. Importantly, a large proportion of these patients did not have close echocardiographic monitoring after hospital discharge and may not have received optimal cardioprotective therapy.

P1-214

Prognostic Value of Inferior Vena Cava Size by Ultrasound in Patients with Heart Failure

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Background: Ultrasound of the inferior vena cava (IVC) is frequently used as a noninvasive method to assess volume status in patients with heart failure (HF). IVC maximum diameter (IVCmax) on admission in patients with HF has been shown to predict adverse outcomes. We conducted a systematic review of the value of IVCmax on discharge and the change in IVCmax during the hospitalization by ultrasound in predicting readmissions and mortality in patients with acute HF. **Methods:** We searched PubMed, EMBASE, and Web of Science for studies published from the inception of the database until February 2018. We included studies with a sample size of 20 or more adult patients with HF, regardless of ejection fraction, that report on the value of IVC size on discharge from the hospital or size change during hospitalization to predict readmission, mortality, or both. **Results:** Of 2261 candidate studies, 4 (n= 48-177 patients) met the inclusion criteria (Table 1). IVC maximum diameter (IVCmax) on discharge significantly predicted readmissions in 2 studies with an adjusted hazard ratio (HR) of 4.75 (95% CI: 1.20-18.72) and an odds ratio (OR) of 10.3. IVCmax at discharge trended toward predicting readmissions and mortality in a third study [HR 1.07 (95% CI: 0.96-1.18)]. A decrease in IVCmax was shown to be a significant protective factor against readmissions in one study with adjusted HR of 0.94 (95% CI: 0.91 - 0.98) per % decrease and against mortality in another with adjusted HR of 0.76 (95% CI: 0.5 - 0.98) per mm (Table 2). **Conclusion:** Although the evidence is limited, both IVCmax on discharge and change in IVCmax during hospitalization appear to predict adverse events such as mortality and readmissions in patients with HF. Research into incorporating serial IVC ultrasound assessment into decision-making may improve clinical outcomes in these patients.

Table 1. Prognostic value of IVCmax at Hospital Discharge in inpatients with Acute Heart Failure.

Study	Design	N	Age	Cohort (EF)	IVC Time	Outcome	Criteria standard (Outcome)
Eshnnnaamtewa 2008	Prospective	75	61 ±15	HFrEF <40%	Within 12 h of admission and before discharge	Readmission or ED visits at 1 month	Chart review and telephone contact
Coiro 2015	Prospective	60	72.1 ± 10.2	HFrEF and HFpEF	Day of discharge	Primary: composite AHF readmission, all cause mortality Secondary: Acute HF readmission, all cause mortality	Chart review and telephone contact at 3 months
Carbone 2014	Prospective	48	Median N-IHD 82 (76-86) IHD 85 (79-87)	HFrEF and HFpEF	Within 12 hours of Admission and day of discharge	Primary: AHF readmission	Weekly telephone contact
DeVecchis 2016	Retrospective	177	74	HFrEF and HFpEF	Admission and discharge	Primary: all cause mortality	-

HFrEF, Heart failure with reduced ejection fraction. HFpEF, Heart failure with preserved ejection fraction.

Table 2. Prognostic value of IVCmax at Hospital Discharge in inpatients with Acute Heart Failure.

Author	N	IVC max cutoff	Follow-up Months	Non adjusted			Adjusted		
				Hospital Admission HR or RR (95%CI)	Mortality HR or RR (95%CI)	Combined HR or RR (95%CI)	Hospital Admission HR or RR (95%CI)	Mortality HR or RR (95%CI)	Combined HR or RR (95%CI)
Gaonewardena 2008	75	>20 mm	1	-	-	-	10.3 (↓ p 0.001	-	-
Coiro 2015	60	>20mm	3	0.97 (0.39-2.40)	-	1.43 (0.56-3.63)	-	-	-
		Continuous	3	1.07 (0.96-1.18)	-	1.11 (1.01-1.23)	-	-	1.09 (0.99-1.19)
Carbone 2014	48	≥18mm	2	-	-	-	4.75 (1.20-18.72)	-	-
		% changes[1]	2	0.95 (0.92 – 0.98)	-	-	0.94 (0.91 – 0.98)	-	-
Devecchis 2016	177	Reduction[2]	6	-	0.77 (0.66-0.90)	-	-	0.76 (0.5 - 0.98)	-

[1]The change of IVCmax during the hospitalization was expressed as percentage [%] rate of [(IVC admission-IVC discharge)/IVC admission].
[2] Reduction in the IVCmax [i.e., expiratory] diameter from admission to discharge expressed as millimeters.

P1-215

How Echocardiography Findings Reveal the Differential Diagnosis Between Glycogen Storage Cardiomyopathy (PRKAG2) and Amyloidosis

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Background: Left ventricle hypertrophy (LVH) is seen in a variety of systemic and genetic diseases. Mutations in the gene for AMP-activated protein kinase (PRKAG2) cause an accumulation of cardiac glycogen and LVH that mimics amyloidosis. The clinical picture of PRKAG2 cardiomyopathy includes sinus bradycardia, AV conduction disturbances, ventricular pre-excitation, and tachyarrhythmia. The amyloid protein deposits in the heart, leading to thick walls and bad prognosis. We aimed to compare echo findings in a cohort of patients (Pts) with PRKAG2 cardiomyopathy and amyloidosis. **Methods:** From 25 Pts with genetically proven PRKAG2 (R302Q), 14 without pacemaker (PM) were selected (mean age 28.9 ± 12.9y, 36% male) and compared to 20 Pts (mean age 64.5 ± 13.4y, 70% male) with biopsy-proven cardiac amyloid (primary/light chain, n= 12, transthyretin with mutation n= 5 transthyretin wild type, n= 3). Both groups were submitted to echocardiographic examination, including M-mode, 2 and 3D measurements, tissue Doppler, and 2D and 3D speckle tracking. All data were reviewed offline using dedicated software. **Results:** Hypertrophy was found in varying degrees in 94% of Pts. Mean left ventricle (LV) septum and LV posterior wall thickness had no statistically significant difference between both groups (13.1 ± 3.8 mm in PRKAG2 group vs. 14.7 ± 3.3 mm in amyloidosis group). No dynamic rest LV outflow tract obstruction was detected in either group. Ejection fraction was reduced in 2 (14%) Pts with PRKAG2 and in 12 (60%) Pts with amyloidosis. Diastolic dysfunction occurred in the majority of Pts in both groups. However, indirect signs of elevated LV filling diastolic pressure were found in 3 (21%) of the PRKAG2 group and in 10 (50%) of the amyloidosis group. Global longitudinal strain (GLS) by 2D speckle tracking measured -18.2% ±-5% in PRKAG2 group and -10.9 ± 3% in amyloidosis group (p <0.001). All Pts with amyloidosis had statistically significant lower GLS, radial, circumferential, and area strain when compared to PRKAG2 Pts. Ejection fraction divided by GLS was 3.8 ± 0.8 in PRKAG2 Pts and 5.3 ± 1.9 in amyloidosis Pts (p = 0.001). 2D speckle tracking longitudinal bull's eye patterns were different for amyloidosis and PRKAG2, which helped to detect differentiation visually. **Conclusion:** Echocardiography is a valuable tool in detecting and differentiating diffuse and focal myocardial abnormalities in PRKAG2 cardiomyopathy and amyloidosis. The deformation indices are especially revealing because they may be helpful in recognizing these LVH diseases, thereby favoring early diagnosis, enhanced treatment, and improved outcome.

P1-216

Is Global Longitudinal Strain Associated with the Histopathologic Burden of Cardiac Amyloidosis?

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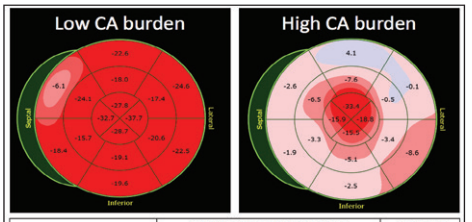
Background: There are a number of emerging therapies for cardiac amyloid (CA). Accordingly, there is a need for imaging-based biomarkers that assess the severity of CA to follow treatment response. Although global longitudinal strain (GLS) has been shown to be an important tool for the diagnosis and risk stratification of CA, it is not known whether differences in GLS can be attributed to the severity of CA involvement. The aim of this study was to evaluate the relationship between GLS and the quantitative burden of CA determined by a histopathologic method we recently developed. **Methods:** We retrospectively identified 34 patients (67.5 ± 9 years, 27% female) with CA who had an echocardiogram and endomyocardial biopsy (EMB). Of these, 3 patients were excluded because of poor quality of images and 5 patients excluded due to history of prior cardiac surgery. Amyloid burden was quantified by a microscopic review of multiple EMB samples by a cardiac pathologist. Patients were divided into 2 groups: low amyloid burden (<50% CA) and high (≥50% CA). Using the American Society of Echocardiography Criteria, left ventricular (LV) end-diastolic volume (EDV), end-systolic volume (ESV), ejection fraction (EF), interventricular septal thickness (IVSt), posterior wall thickness (PWt), lateral e' and GLS were measured. Each of these parameters was compared between the two CA burden groups using student's t-test. **Results:** Of the 26 patients, 27% of patients had AL amyloid, 73% had TTR amyloid. Fifteen patients had a low burden of CA and 11 had a high burden of CA. In patients with a high burden of CA: (1) LVEF and lateral e' were lower; (2) IVSt, PWt and LV mass were increased, and (3) GLS was worse (Table). **Conclusions:** We found that several echocardiographic parameters including GLS are associated with the histopathologic CA burden, and thus may potentially be useful as imaging-biomarkers to detect changes in CA burden in response to treatment.



Echocardiographic Parameters	Cardiac Amyloid Burden		p-value (t-test)
	Low (0-49%) (n=15)	High (50-100%) (n=11)	
LVESV (ml)	58 ± 21	90 ± 49	0.03
LVEDV (ml)	124 ± 24	125 ± 56	0.95
LVEF (%)	53 ± 15	30 ± 11	0.0003
GLS (%)	-10.7 ± 4.9	-6.4 ± 3.7	0.03
IVSt (cm)	1.47 ± 0.3	1.89 ± 0.3	0.003
PWt (cm)	1.45 ± 0.2	1.89 ± 0.3	0.001
Lateral e' (cm/s)	5.9 ± 2.2	4.2 ± 1.4	0.07
LV mass (g)	288 ± 88	357 ± 68	0.04

Poster Session 1 (P1)

Sunday, June 24, 2018

P1-217

Assessing the Cause of Pulmonary Hypertension on Echo in the Absence of Tricuspid Regurgitation - a National Echo Database of Australia Study

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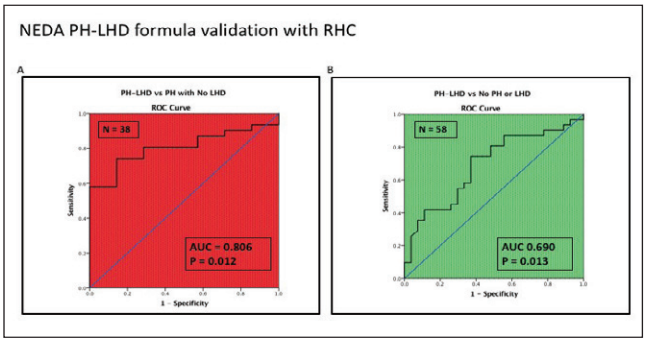
Background: PH-LHD is the most common cause of pulmonary hypertension (PH), associated with a high risk of death. Echo diagnosis of PH usually relies on a measurable TRV, but sufficient TR is absent in up to 40% of patients. Using the NEDA, we have previously described a method for predicting PH-LHD in the absence of a measurable TR velocity. Using age, E' velocity, E/E' ratio, E/A and left atrial volume index (LAVI) we created a model to diagnose PH-LHD. Tested in a cohort of 151,767 echos, our model is highly accurate in diagnosing PH-LHD. The NEDA PH-LHD Constant is ((Con) =-6.649 + (0.035 x Age) + (0.072 x E') + (0.077 x E/E') + (0.509 x E/A) + (0.03 x LAVI)), and the probability of having PH due to left heart disease = [EXP (Con) /[1+ (EXP(Con))] Aim: To validate the NEDA PH-LHD predictive model in patients undergoing right heart catheterisation. **Methods:** We analysed 887 consecutive patients from a West Australian tertiary centre who underwent RHC. They were divided into three groups: Group 1- those with PH-LHD (mPAP ≥ 25mmHg and PCWP ≥ 15mmHg), Group 2 - those with PH not due to LHD (mPAP >25mmHg and PCWP < 15mmHg) and Group 3 - those with no PH or LHD (mPAP <25mmHg and PCWP <15mmHg). To validate the NEDA PH-LHD model we compared Group 1 vs Group 2 in our first analysis and Group 1 vs Group 3 in our second analysis. We then applied these two probability analyses to a ROC curve to establish the accuracy of our model in predicting PH-LHD using RHC. **Results:** Age and the severity of PH was similar across groups, irrespective of causality. PVR was normal in those without PH, but was increased in patients with PH including those with PH-LHD suggesting a degree of pre-capillary PH in these patients. Patients with PH-LHD had higher left atrial filling pressures (PCWP=24.8+/-7mmHg, E/E'=21+/-10, E/A=1.7+/-1.1)(p=<0.0001). Figure 1 illustrates that the accuracy of our formula is 80% predictive in identifying patients with PH-LHD vs those with PH but no LHD, and 70% accurate in predicting PH-LHD when applied to patients with PH-LHD against those with no PH or LHD. **Conclusion:** In the absence of TRV, the NEDA PH-LHD model is 80% accurate in identifying patients with PH-LHD validated against RHC. Using only age and diastolic echo markers, our model is suited as an addition to echo software to automatically identify those likely to have PH who need further investigation.



P1-218

Prognosis of Patients with Reverse Stress-Induced Cardiomyopathy When Compared to Other Subtypes

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Background: Stress-induced cardiomyopathy (SCM) is characterized by an acute and transient left ventricular dysfunction. Most of the patients with SCM survive and have a good prognosis. However, the prognosis according to SCM subtypes is unclear since there is limited data for clinical characters and prognostic factors according to the subtypes. We investigated the prognosis of patients with SCM according to the subtypes. **Method:** Patients that had a diagnosis of SCM confirmed by diagnostic coronary angiography and transthoracic echocardiography were retrospectively reviewed from April 2015 to October 2016. We classified the as two groups. One was the reverse SCM group, whose predominate location of the regional left ventricular dysfunction was in the basal LV wall. The other group included classic as well as other SCM subtypes. Clinical and echocardiographic findings were compared between the two groups. The primary outcome was that all-cause death during follow-up. **Results:** Of 52 patients, 39 patients were allocated to the classic and other SCM group while 13 patients reverse SCM group. Among the 52 patients, six patients (11.5%) died during a mean follow-up period of 8.8 ± 5.9 months (median 8.5 months). In addition, 5 patients (9.6%) died within 1 month. The incidence of all cause death was significantly higher in the reverse SCM group compared with the classic and other SCM group (30.8% vs. 5.1%, $p = 0.029$). The incidence of 30-day all cause death was also significantly higher in the reverse SCM group in comparison to the classic and other SCM group (30.8% vs. 2.6%, $p = 0.011$). In addition, the cumulative death free survival rate was significantly lower in the reverse SCM group when compared to the classic and other SCM group (69.2% vs. 94.9%, Log Rank $p = 0.012$). This was also the case for the cumulative 30-day survival rate (69.2% vs. 97.4%, Log Rank p = 0.003). After adjustment for all the possible confounding factors, using the Cox proportional hazard regression analysis, reverse type was shown to have a 13.5 fold increased hazard for all cause death (odds ratio 13.5, 95% CI 1.599-114.554, $p = 0.017$). **Conclusion:** In patients with SCM, all-cause death rate was increased in the reverse subtype as compared to other types. Reverse SCM has been shown to be a good prognostic factor of death, even when taking into account the clinical confounding factors. Patients with SCM need focused evaluation of the predominant left ventricular dysfunction location in order to predict prognosis and appropriate treatment.

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Non-Alcoholic Fatty Liver Disease in Patients without Hypertension is Associated with Decreased Left Ventricular Dimensions and Mass

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Background: Hypertensive individuals with non-alcoholic fatty liver disease (NAFLD) have been reported to have increased left ventricular (LV) mass. Whether similar findings are observed in non-hypertensive individuals is not clear. **Methods:** We compared left heart measurements between adults with and without NAFLD in a cohort of 24,662 individuals with an echocardiogram, and after excluding those with left-sided valve disease, myocardial infarction, decreased left ventricular function, or hypertension. **Results:** There were differences between groups in demographics, comorbidities, and left heart dimensions (Table 1). After multivariate adjustment, individuals with NAFLD (vs. without) had decreased indexed LV end-diastolic diameter (-1.1mm/m^2, 95% CI -0.8 to -1.4, p<0.001), LV end-systolic diameter (-0.9mm/m^2, 95% CI -0.6 to -1.2, p<0.001); septal wall thickness (-0.1mm/m^2, 95% CI -0.03 to -0.3, p=0.01); LV mass (-2.8gm/m^2, 95% CI -1.0 to -4.9, p=0.01), and aortic root diameter (-0.6mm/m2, 95% CI -0.4 to -0.9, p<0.001); there was no difference in indexed posterior wall thickness (p=0.10) or left atrial diameter (p=0.70). Those with NAFLD had lower adjusted peak tricuspid regurgitation gradient (-1.9 mmHg, 95% CI -0.2 to -3.6 mmHg, p=0.03). **Conclusion:** Non-hypertensive individuals with NAFLD had decreased LV dimensions and mass, and lower tricuspid regurgitation gradients when compared to controls. This contrasts with prior findings of increased LV mass in hypertensive individuals with NALFD, and suggests the absence of hypertension is associated with an absence of cardiac remodeling in this population.

Table 1. Left Heart Measurements in Those With versus Without NAFLD

	NAFLD (n=503)	No NAFLD (n=24,159)	p
Demographics and Medical History			
Age	50.9±12.3	51.7±16.7	0.29
Female gender	50.1%	55.8%	0.01
Body mass index	32.8±7.4	28.7±7.3	<0.001
Body surface area	2.0±0.3	1.9±0.3	<0.001
Tobacco use	47.0%	44.4%	0.32
Diabetes	27.3%	7.3%	<0.001
Measurements (mm, gm, or mmHg)			
LV End-Diastolic Diameter	46.8±5.5	46.8±5.6	0.84
LV End-Systolic Diameter	29.7±5.3	30.1±5.4	0.15
Interventricular Septum	9.5±1.7	9.4±2.3	0.16
Posterior Wall	9.4±1.5	9.1±1.8	<0.001
LV Mass	153.5±43.3	149.7±53.3	0.11
Left Atrial Diameter	38.8±5.7	37.0±6.8	<0.001
Aortic Root Diameter	31.5±4.0	31.4±4.5	0.72
Peak Tricuspid Regurgitation Gradient	23.2±6.6	25.8±12.1	0.002
Measurements Indexed to BSA (mm/m² or gm/m²)			
LV End-Diastolic Diameter/BSA	23.1±3.0	24.6±3.4	<0.001
LV End-Systolic Diameter/BSA	14.7±2.7	15.8±3.0	<0.001
Interventricular Septum/BSA	4.8±0.9	5.1±1.2	<0.001
Posterior Wall/BSA	4.7±0.8	4.9±1.2	0.003
LV Mass/BSA	74.7±17.3	77.1±23.2	0.03
Left Atrial Diameter/BSA	19.2±2.9	19.3±3.4	0.32
Aortic Root Diameter/BSA	15.6±2.2	16.5±2.5	<0.001

BSA, body surface area; LV, left ventricle; NAFLD, non-alcoholic fatty liver disease

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Sunday, June 24, 2018

P1-220

Left Ventricular Shape Components Correlate With Pulmonary Arterial Pressure

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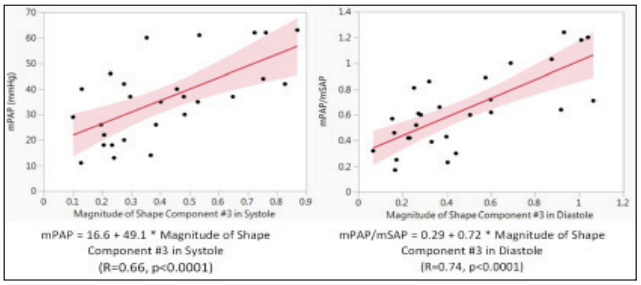
Background: Although cardiac catheterization is the gold standard for diagnosis and surveillance of pediatric pulmonary hypertension (PH), it carries significant risks. Robust echocardiographic measures to predict mean pulmonary artery pressure (mPAP) could allow a non-invasive means to follow PH patients. We hypothesized that a novel method of evaluating left ventricular (LV) shape would correlate with simultaneous invasive hemodynamics. **Methods:** Simultaneous echocardiography and invasive hemodynamics were obtained in 28 patients during cardiac catheterization for PH. TomTec Software (Unterschleissheim, Germany) was used to trace the LV from the parasternal short-axis view. A Fourier transform decomposed LV shape, in each frame, into a series of shape components and magnitudes. Magnitudes were normalized to heart size (magnitude/LV length as measured on apical 4 chamber view) and averaged across 3 beats to account for beat-to-beat variability. Shape component magnitudes were compared against mPAP and mean pulmonary-to-systemic arterial pressure ratio (mPAP/mSAP). Correlations were assessed using bivariate and multivariate linear regression. **Results:** Significant correlation was observed between the 3rd shape component (a triangular shape) and both mPAP in systole and mPAP/mSAP in diastole. Multivariate regression using the 3rd and 7th shape components displayed a significant correlation with mPAP in systole (R=0.77, p<0.0001). **Conclusion:** LV shape deformation with flattening of the ventricular septum is common in PH. Our novel method of quantifying LV deformation using Fourier shape analysis demonstrates the potential to serve as a non-invasive means to safely and efficiently estimate mPAP. This method offers advantages over eccentricity index (EI), such as the ability to precisely and dynamically quantify LV shape. Further analysis of LV shape component data, both spatially and temporally, is underway to evaluate the accuracy and performance of ventricular shape modeling with respect to other measures such as EI.



P1-221

The Utility of Strain in Prediction of Mortality at 1 Year in Takotsubo Cardiomyopathy

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Background: Takotsubo Cardiomyopathy (TC) is an acute heart failure syndrome that has increasingly recognized morbidity and mortality in select patients. Two-dimensional speckle-tracking echocardiography (2DSTE) has demonstrated that abnormal myocardial deformation indices persist beyond recovery in left ventricular ejection fraction (LVEF). The aim of this study was to evaluate the association of 2DSTE calculated strain and death at 1 year. **Methods:** We retrospectively identified patients with an ICD9/10 diagnosis of TC using Northwestern University Enterprise Data Warehouse. Using TOMTEC Arena 2.21 software, we obtained peak global longitudinal strain (GLS), peak global circumferential strain (GCS), and peak global radial strain (GRS) from the presenting echocardiogram at time of TC diagnosis. LVEF was also obtained from the echocardiogram report. The patient outcome of death within 1 year was identified by ICD9/10 codes. Statistical analysis was performed using multivariate logistic regression with a p-value of <0.05 considered significant. **Results:** We included 77 subjects in our study, mean age 66.5 years +/- 15.3, 82% female. Seven subjects died at 1 year. Multivariate logistic analysis of the above parameters revealed presenting GCS, and not GLS, GRS, or LVEF, to be independently associated with death at 1 year (OR: 0.767, p = 0.043). **Discussion:** In our single-center study of patients with TC, only presenting peak GCS was associated with death at 1 year. Circumferential strain has an important role in prognostication that has yet to be fully explored in TC.

Table 1: Strain and relationship to death at 1 year

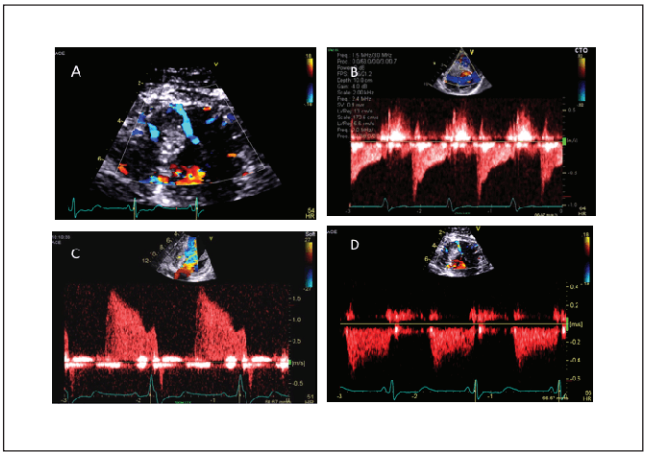
Strain Type or EF	Odds Ratio	P-value
Peak GLS	0.996	0.978
Peak GCS	0.767	0.043
Peak GRS	0.853	0.206
LVEF	0.877	0.326

P1-222

Septal Perforator Doppler Profiles in Hypertrophic Cardiomyopathy Patients

Patrycja Galazka, Renuka Jain, Lindsey Kalvin, Fuad Jan, Susan Olet, Bijoy Khandheria, Jamil Tajik. Aurora Health Care, Milwaukee, WI

Background: Hypertrophic cardiomyopathy (HCM) is associated with alterations in coronary flow especially in the smaller vessels secondary to intimal proliferation, medial hypertrophy and microvascular fibrosis. Color Doppler allows visualization of arterial flow within the hypertrophic myocardium. We assessed the feasibility of septal perforator artery visualization and characterized the flow velocity profile in HCM patients. **Methods:** We prospectively evaluated 106 HCM patients who were seen at the Aurora Hypertrophic Cardiomyopathy Center over a six month period. Using low Nyqist limits, we located and recorded septal perforator peak diastolic velocity, slope of the diastolic velocity, end diastolic velocity, atrial dip, and systolic flow reversal velocity. Other echocardiography parameters (left ventricular (LV) septal thickness, LV ejection fraction, LV global longitudinal strain, left atrial volume index, mitral E and A velocities, LV e' septal and lateral velocities, LV a' septal and lateral velocities and E/e' ratios) were collected. All patients were in sinus rhythm. **Results:** We were able to visualize septal perforator color flow in 95 out of 106 (90%) patients. Spectral Doppler profile of these perforators was recorded in 57 of 95 (60%) patients (Figure Panel A), average septal thickness in these patients was 2.4 cm (SD = 0.49). Three different patterns of the septal perforator Doppler flow emerged: 1) systolic and diastolic flow with atrial dip in 20 (35%) patients (Figure Panel B); 2) systolic and diastolic flow without atrial dip in 20 (35%) patients (Figure Panel C); 3) diastolic profile only in 17 (30%) patients (Figure Panel D). Patients who had atrial dip profile had higher diastolic slope of the diastolic velocity profile (mean 111.2 cm/s^2 vs 65.1 cm/s^2 (p=0.0248).**Conclusions:** We demonstrate the feasibility of visualization of septal perforator Doppler flow in the vast majority of HCM patients with currently available technology. Full spectral septal perforator Doppler profile was possible in 60% of patients. The profile of systolic flow reversal (milking effect) of systolic compression of septal perforators was noted. In addition, we found correlations between flow velocity profile and markers of diastolic dysfunction in these patients. Future clinical studies are warranted.



P1-223

Diastolic Dysfunction is Common in Systemic Sclerosis and Portends a Poor Prognosis

Alicia M. Hinze, Laura K. Hummers, Fredrick M. Wigley, Ami A. Shah, Monica M. Mukherjee. Johns Hopkins University, Baltimore, MD

Background: Heart disease in systemic sclerosis (SSc) often goes unrecognized until severe clinical manifestations are present. Diastolic dysfunction (DD) may identify patients at risk for cardiac complications by distinguishing the subset with myocardial fibrosis. The aims of this study were to 1) determine the prevalence of non-valvular DD in SSc according to the 2016 ASE/EACVI guidelines, 2) evaluate the impact of DD on survival in patients with SSc, and 3) assess cardiac risk factors for DD in SSc. **Methods:** 491 subjects with SSc seen between 11/01/2007 and 10/31/2017 were included. If a subject had more than one 2DE in this time period, the most recent technically adequate 2DE was included. Subjects were excluded from the study if they had moderate to severe mitral or

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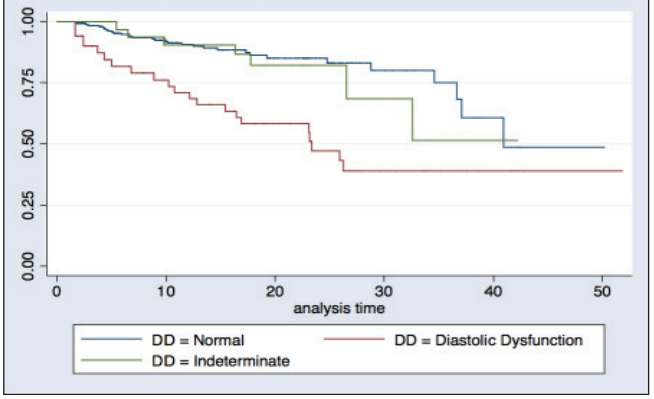
aortic valve disease, a primary cardiomyopathy, a recent myocardial infarction, or were admitted to an intensive care unit. DD presence and grade were determined according to the 2016 ASE/EACVI guidelines. **Results:** DD was present in 14% of SSc subjects (91% with grade 2 and 9% with grade 3). Median age was 57 years (IQR 47 - 66). Subjects with DD had worse survival, as compared with subjects with no DD or indeterminate DD (Figure 1, log-rank test for equality of survival <0.007); these findings persisted even after adjusting for age on Cox proportional hazards model (HR 2.17, 1.08 - 4.37). On multivariable regression analyses examining common risk factors for DD including hypertension, renal disease, coronary artery disease (CAD), obesity, diabetes and chronic obstructive pulmonary disease, only CAD (16.77, 4.40 - 63.83), obesity (5.62, 2.56 - 12.31) and increasing year of age (OR 1.14, 1.10 - 1.18) were significantly associated with DD. The presence of restrictive lung disease (RLD) (FVC≤65) was also a risk factor for DD, after adjusting for comorbid disease (OR 2.24, 1.11-4.52). **Conclusion:** DD is common in the SSc and is present at moderate to high grades. RLD was a unique risk factor for DD in SSc, as well as more common risk factors of CAD, obesity, and increasing age. This SSc population was relatively young, suggesting that SSc may represent an accelerated model of DD that may be unique to the underlying disease process. The presence of DD is associated with a poor prognosis, therefore, being aware of DD and its risk factors is important in managing a patient with SSc.

Figure 1. Increased all-cause mortality in SSc subjects with diastolic dysfunction in comparison to SSc subjects with indeterminate or normal diastolic function.



Poster Session 2 (P2)

POSTER SESSION 2 (P2)

Presented Monday, June 25, 9:00 AM-6:30 PM

Value of Echocardiography (Quality and Cost) / Comparative Effectiveness
P2-01 through P2-25

Critical Care Ultrasound / Point of Care Ultrasound
P2-26 through P2-35

New Technology
P2-36 through P2-69

Contrast Echocardiography
P2-70 through P2-77

Intraprocedural Echocardiography (Operating Room and Interventional Lab) / TEE
P2-78 through P2-87

Echocardiography in SOE / Arrhythmias / Atrial Function
P2-88 through P2-107

Ischemic Heart Disease
P2-108 through P2-117

Ventricular Function / Myocardial Mechanics
P2-118 through P2-157

Clinical Cases: Adult Patients
P2-158 through P2-223

P2-01

Impact of Repeat Echocardiograms on Management Decisions in Patients Rehospitalized with Acute Decompensated Heart Failure

Lindsey Aurora, Sarah Gorgis, Chaun Gandolfo, Omar Sadiq, Meredith Mahan, Karthikeyan Ananthasubramaniam. Henry Ford Hospital, Detroit, MI

Background: Transthoracic echocardiography (TTE) at the time of acute decompensated heart failure (ADHF) may reveal significant structural and hemodynamic abnormalities that can classify risk, guide clinical management, and aid resource utilization. TTE is considered appropriate for enhancing diagnosis and guiding downstream management. However, the clinical impact of routine repeat TTE in uncomplicated ADHF re-admissions is yet to be established. We studied patients with repeat TTE at the time of re-hospitalization for ADHF to determine the clinical impact of TTE. **Methods:** In a single center retrospective study, 413 adult patients with 2 ADHF admissions within 1 year period were studied. Those with clear indications for repeat TTE (myocardial infarction, stroke, arrhythmias, hemodynamic instability, or valve disease) were excluded. 198 patients met inclusion criteria. Two groups were defined: those with significant interventions (SI: heart catheterizations, other cardiac procedures, nuclear scans, or specialty consultations) and minimal interventions (MI: medication or no changes). Demographic data, echocardiography parameters, procedures, and medications changes were evaluated. **Results:** Out of 198 patients, 85 patients comprised the SI group and 113 patients were in the MI group. Non-ischemic cardiomyopathy was the predominant etiology of heart failure observed in both groups (p=0.251). BNP on second presentation of ADHF was statistically worse than the prior admission (p=0.014). As a result of repeat TTE, no significant changes in left ventricular ejection fraction were observed in both groups MI and SI (p=0.131 and p=0.236, respectively). Within the valve disease subgroup, those with underlying mitral regurgitation who underwent MI had significant improvement of their valvular disease (p=0.005). This effect was not noted in patients who had advanced interventions (p=0.141). Despite SI, those patients with diastolic dysfunction trended to worsen despite repeat TTE (p=0.074). **Conclusion:** Many patients undergo repeat TTE routinely in the setting of ADHF. In our results, the predominant impact of repeat TTE in re-hospitalized ADHF involved minimal interventions such as medication changes, rather than significant interventions including procedures or specialty consultations. Echocardiography continues to serve an important role in patient management decisions, but clinicians should focus on reserving utilization of repeat

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Sunday, June 24, 2018

TTE in uncomplicated ADHF readmissions to those not responding to standard medical optimization and diuresis.

P2-02

Is Upper Endoscopy Required in Cirrhotic Patients Prior to TEE?

Ellen Liu, Avirup Guha, Michael Dunleavy, Timothy Obarski. The Ohio State University, Columbus, OH

Background: Transesophageal echocardiogram (TEE) has been shown to be a relatively safe procedure with a low complication rate. Patients with liver disease pose a risk to invasive procedures such as TEEs given the associated prevalence of esophageal varices and coagulopathy that can increase bleeding risk. There are currently no guidelines for or studies pertaining to obtaining an upper endoscopy (EGD) prior to TEE in cirrhotic patients. **Methods:** Retrospective analysis of cirrhotic patients >18 years old at The Ohio State University Medical Center who underwent TEE with or without EGD between 1/1/2010 and 12/31/2017 was performed. Patients who underwent EGD within one year prior to TEE were included in the study group. Those without a documented EGD or who underwent EGD greater than one year pre-TEE were included in the control group. Patients were followed for 7 days post-TEE for adverse events. Data was collected including demographics, medical history, etiology of cirrhosis, TEE safety checklist (esophageal and oral pathology related) and laboratory values. All possible TEE complications were recorded. Outcomes included adverse events in 24 hours, 7 days and death. Demographics and complications were analyzed using Chi-Square test, T-test and univariate regression analysis where appropriate. **Results:** 127 patients were included in the study, 30.7% female, mean age 58 ± 11. The most common indication for TEE was endocarditis with 76/127 patients (59.8%). Overall mortality from TEE itself was 0%. In patients who had an EGD >1 year pre-TEE or in those with documented varices by EGD, there were no increases in TEE-related complications compared to those patients with an EGD within 1 year or those without varices. The difference in complication rate was not significant (p = 0.25). Patients with an EGD within one year had a higher rate of known varices, ascites, esophageal abnormalities, renal failure and elevated INR. **Conclusions:** TEE in patients with cirrhosis, documented esophageal varices without active bleeding, and EGDs >1 year from the study do not exhibit an increased risk of bleeding complications from the TEE. This preliminary study suggests that performing routine EGDs prior to a TEE in cirrhotic patients to exclude the presence of varices and reduce the risk of TEE-related complications may not be warranted.

Variable	TEE without EGD (N=68)	TEE with EGD (N=59)	P-value
Age	58 ± 11.2	58.5 ± 9.9	0.91
Female	20 (29.4%)	19 (32.2%)	0.14
BMI	33.5 ± 9.6	32.4 ± 8.9	0.49
Race			0.55
Non-white, non-Hispanic	10 (14.7%)	6 (10.2%)	
Non-white Hispanic	1 (1.5%)	2 (3.4%)	
White non-Hispanic	57 (83.8%)	51 (86.4%)	
White Hispanic	0	0	
TEE Indication			0.94
Endocarditis	40 (58.8%)	36 (61.0%)	
Atrial fibrillation	14 (20.6%)	9 (15.3%)	
Transplant work-up	0	1 (1.7%)	
Murmur	0	1 (1.7%)	
Other	14 (20.6%)	12 (20.3%)	
Peri-procedural questions/sedation			
History of varices	12 (17.6%)	35 (59.3%)	<0.0001
History of ascites	23 (33.8%)	29 (49.2%)	0.03
History of GI bleed	4 (5.9%)	11 (18.6%)	0.47
History of esophageal abnormalities	1 (1.5%)	8 (13.6%)	0.0085
History of dysphagia or odynophagia	2 (2.9%)	0	0.21
History of esophagitis	2 (2.9%)	3 (5.1%)	0.29
History if hepatocellular carcinoma	6 (8.8%)	3 (5.1%)	0.2
Sedation use			0.054
Midazolam	61 (89.7%)	50 (84.7%)	0.15
Fentanyl	57 (83.8%)	44 (74.6%)	0.07
Cirrhosis type			0.25
NASH	11 (16.2%)	11 (18.6%)	
Alcoholic	11 (16.2%)	13 (22.0%)	
Hepatitis C	20 (29.4%)	14 (23.7%)	
Other hepatitis	3 (4.4%)	1 (1.7%)	
A1AT	0	3 (5.1%)	
Autoimmune	1 (1.5%)	1 (1.7%)	
Cryptogenic	5 (7.4%)	6 (10.2%)	
Other	13 (19.1%)	4 (6.8%)	
Mixed	5 (7.4%)	6 (10.2%)	
Baseline Clinical Characteristics			
Hypertension	42 (61.8%)	31 (52.5%)	0.08
DM	37 (54.4%)	29 (49.2%)	0.49
CAD	19 (27.9%)	12 (20.3%)	0.1
Stroke	6 (8.8%)	2 (3.4%)	0.14
Afib	33 (48.5%)	26 (44.1%)	0.68
CHF	30 (44.1%)	15 (25.4%)	0.07
LVEF	54.0% ± 11.3%	53.3% ± 9.9%	0.73
OSA	16 (23.5%)	20 (33.9%)	0.16
Medication use			
Aspirin	32 (47.1%)	20 (33.9%)	0.047
Plavix	6 (8.8%)	2 (3.4%)	0.09
Coumadin	14 (20.6%)	12 (20.3%)	0.17
Lovenox	9 (13.2%)	6 (10.2%	0.19
DOAC	6 (8.8%)	2 (3.4%)	0.14
Beta-blocker	34 (50.0%)	30 (50.8%)	0.14
Lab Values at time of TEE			
Sodium	135 ± 4	135 ± 3.1	0.91
Potassium	4 ± 0.7	4.1 ± 0.5	0.93
Creatinine	2.3 ± 2.5	1.2 ± 1.0	0.004
Bilirubin	2.1 ± 5.3	2.6 ± 4.3	0.56
Hgb	10.6 ± 2.4	10 ± 2.4	0.12
MELD-Na	18.9 ± 5.2	18.7 ± 6.1	0.9
INR	1.4 ± 0.4	1.8 ± 1.0	0.02
Platelet	163.2 ± 91.2	131.6 ± 97.3	0.06

P2-03

The Impact of IAC-Echo Accreditation on Major and Minor Diagnostic Errors in Transthoracic Echocardiogram Interpretation

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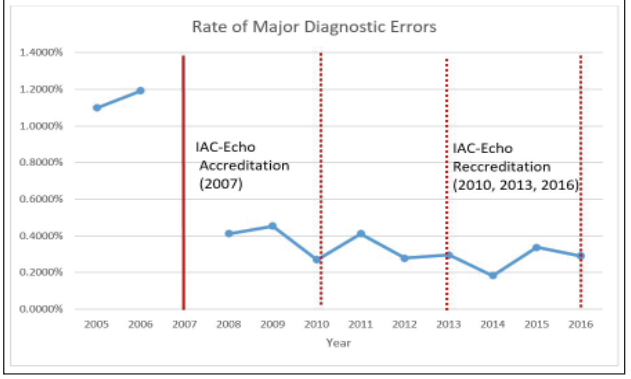
Background: To standardize TTE and reduce error rates, the ASE has called for quality assurance TTE protocols and the Intersocietal Accreditation Commission (IAC) has developed standards for IAC-Echo accreditation. However, there are no published data examining whether accreditation improves TTE interpretation. We sought to examine the rate of major diagnostic errors in TTE interpretations at a large medical center prior to and after their first IAC accreditation. **Methods:** Prior reports at our institution are reviewed after interpretation of each TTE. If the interpretations differ, the prior *images* are reviewed and agreement/disagreement with the prior interpretation is recorded in a database with the latter coded as "minor" or "major" error (findings that would have necessitated an acute change in patient care and include ventricular dysfunction, severe valve disease, or significant pericardial effusion). For this study, major errors on studies performed after 2005 (digital PACS) were independently re-adjudicated by two, blinded TTE readers to determine if the disagreement/error was a true major error. Excluding studies from 2007 (year of initial IAC-Echo accreditation), major error rates were compared before and after 2007 using a Chi Square analysis. To control for changes in physician staffing, a sub-analysis was done for the 4 providers who read studies prior to and after 2007. **Results:** From 2005 to 2016, 39,939 TTE "over-reads" were performed by 20 different physicians with 169 (0.42%) studies identified as having major errors. There was a 74% reduction in major errors *after* IAC accreditation (1.17% vs. 0.32%, RR = 3.58; p = <0.001; FIGURE) with a 39% reduction in minor errors (11.7% vs. 7.1%, RR = 1.65; p = <0.001). There was no change after IAC-Echo reaccreditation (2010, 2013, 2016). Sub-analysis of data from the 4 providers who read studies before and after initial IAC-Echo accreditation demonstrated a near 50% reduction in major disagreements (0.66% vs. 0.34%, RR = 1.94; p= 0.08). **Conclusion:** Initial IAC-Echo accreditation is associated with a marked reduction in major and minor errors in TTE interpretation, with maintained low rates pre/post reaccreditation. This is the first study to describe error rates in TTE interpretation in adult patients and their relationship to IAC-Echo accreditation.

Figure 1: Rate of Major Diagnostic Errors in TTE interpretation over time



P2-04

Implementation of a Best Practice Alert in the Electronic Medical Record Impacts Inpatient Transthoracic Echocardiogram Orders

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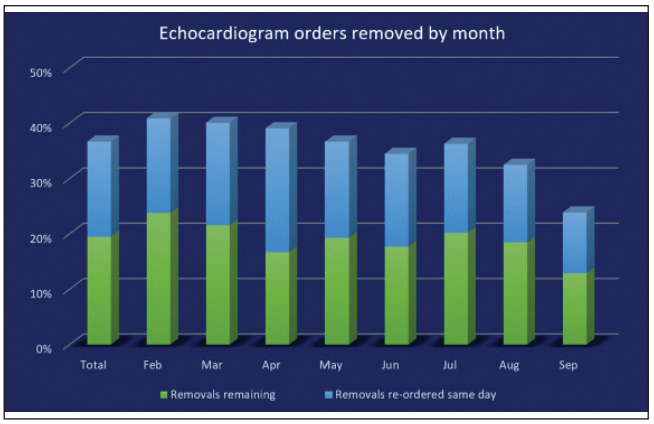
Background: There are increasing efforts nationally and at our institution to reduce lower value care, including within the area of imaging studies such as transthoracic echocardiography (TTE). **Methods:** In an effort to avoid repeating unnecessary studies on inpatients who recently underwent TTE, we implemented a best practice alert (BPA) in our electronic health record to notify ordering clinicians that a TTE had been performed in the past 6 months. The BPA requires the ordering clinician to acknowledge the alert and provide a reason for proceeding with the order and provides a link to ASE Appropriate Use Criteria. Data on initial use was reviewed after approximately 6 months (2/16/17 - 9/12/17.) This included number of TTE orders removed, number re-ordered within the same day, subspecialty of ordering clinician, type of ordering clinician (MD vs NP), and length of stay in patients with orders that were confirmed vs removed. Independent T-tests, Chi-Square, and Fisher Exact tests were used for analysis. **Results:** Over 209 days, the BPA triggered 3,226 times with 37% of these TTEs cancelled by the ordering clinician. Of the orders cancelled, 556 (47%) went on to have an order replaced on the same date. Overall, 20% of the originally ordered echocardiograms remained cancelled after 24 hours. The proportion of removed echo orders decreased over time. There were no statistically significant differences in the proportion of removed TTE

orders between subspecialties or types of clinician (p=0.144.) There was no statistically significant difference in the length of stay in patients with orders kept (9.2 days) compared to orders cancelled (10.5 days). **Conclusions:** An electronic health record alert triggered by an order for an inpatient TTE within 6 months of a prior study effectively reduced study volume by 20%.



P2-05

Application of Pediatric Appropriate Use Criteria for Initial Outpatient Evaluation of Asymptomatic Patients with Abnormal Electrocardiograms

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Background: In the pediatric Appropriate Use Criteria (AUC), abnormal EKG in an asymptomatic patient (indication 52) has been rated as an "Appropriate" indication for transthoracic echocardiogram (TTE). This indication is not further stratified based on the type of EKG abnormality. The purpose of this study was to determine the yield of abnormal findings on TTEs ordered for indication 52 and the type of EKG abnormalities associated with abnormal TTE findings. **Methods:** All patients (≤ 18years) from January 1, 2015-December 31, 2017 who underwent initial outpatient evaluation at our center and had a TTE ordered for AUC indication 52 were included. Clinic records were reviewed to note the specific EKG abnormality and TTE results and determine if the abnormality noted on TTE was related to the EKG or an incidental finding. **Results:** Study population included 206 patients. Of these 93.7% had a normal TTE (81.6% with no findings and 12.1% with a patent foramen ovale or peripheral pulmonary artery stenosis). Thirteen patients (6.3%) had abnormal findings on TTE. The type of EKG abnormalities and TTE findings are shown in the Table. Incomplete right bundle branch block (IRBBB) had the highest yield of abnormal TTE findings (7/27, 25.9%) with a secundum atrial septal defect (ASD) being the most common abnormal finding (5/7, 71.4%). The odds of an abnormal finding with IRBBB on EKG were significantly higher compared to other findings (OR 10.1, 95% CI (3.1-33.0), p<0.001). The odds of TTE abnormalities were further increased with EKG findings of IRBBB, right axis deviation or right ventricular hypertrophy compared to other EKG findings (OR 15.7, 95% CI (3.4-73.4), p<0.001). Left ventricular hypertrophy was the most common EKG abnormality for which TTE was performed but had only one incidental abnormality (tiny inaudible patent ductus arteriosus). **Conclusions:** The yield of abnormal findings on TTE performed for abnormal EKG in asymptomatic pediatric patients is low. EKG abnormalities suggestive of right heart disease including IRBBB, right axis deviation and right ventricular hypertrophy were associated with a much higher yield of abnormal findings compared to other abnormalities. Future revisions of AUC document should consider further stratification of indication 52 by the type of EKG abnormality to improve appropriate use of TTE.

Specific EKG abnormality	Number (%)	Number of TTE abnormalities	Specific TTE abnormality	TTE abnormality related to indication
IRBBB	27 (13.1%)	7	Small secundum ASD (3) Moderate secundum ASD (2) Bicuspid aortic valve without stenosis (2)	Yes Yes No
Right ventricular hypertrophy	20 (9.7%)	2	Small secundum ASD Tiny muscular ventricular septal defect	Yes No
Right axis deviation	14 (6.8%)	2	Small secundum ASD Moderate secundum ASD	Yes Yes
Left ventricular hypertrophy	44 (21.3%)	1	Tiny inaudible patent ductus arteriosus	No
Ectopic atrial rhythm	6 (2.9%)	1	Small secundum ASD	Yes
Other	25 (12.2%)	0		
Left axis deviation	14 (6.8%)	0		
ST-T wave changes	11 (5.4%)	0		
Bi-ventricular hypertrophy	11 (5.4%)	0		
Right atrial enlargement	11 (5.4%)	0		
Premature ventricular contraction	9 (4.3%)	0		
Pre-excitation	8 (3.8%)	0		
1st degree atrio-ventricular block	6 (2.9%)	0		

P2-06

Performance of Comprehensive Transesophageal Echocardiography: Quality Improvement Through Educational Intervention

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Background: Routine performance of comprehensive transesophageal echocardiography (TEE) is recommended by guidelines and required for laboratory accreditation by the Intersocietal Accreditation Commission (IAC). Educational intervention improves quality in transthoracic echocardiography, but no studies on TEE imaging exist. We aimed to evaluate TEE comprehensiveness (TEE-C) in an IAC-accredited lab, identify influencing factors, and assess the efficacy of educational intervention. **Methods:** Using a quantitative scoring system for TEE-C (Table 1), we retrospectively reviewed 186 consecutive studies performed in our lab by 9 echocardiographers. We then provided targeted educational feedback with individual scoresheets and group lectures. In the 3 months thereafter, we prospectively assessed TEE-C in 69 studies. **Results:** Patient and study characteristics were similar pre- and post-intervention (Table 2). Inpatient status, location, and type of anesthesia did not affect TEE-C (Table 3). However, TEE exams to primarily assess the left atrial appendage were less complete (24.8 ± 4.6 vs. 26.3 ± 3.9, p = 0.005). Post-intervention, TEE-C improved overall (28.1 ± 3.1 vs. 25.7 ± 4.2, p < 0.001) and per individual, but time to perform did not increase (mean 25:21 ± 8:53 minutes). Components of TEE-C that improved most were views of the pulmonary artery (51% vs. 23%) and ascending aorta (51% vs. 28%). **Conclusion:** Quality echocardiographic lab operations involve routine performance of comprehensive TEE. Our study shows that quantitative assessment coupled with educational feedback provides an effective framework for improving TEE-C. Further studies are needed to evaluate the clinical impact of comprehensive TEE performance.

Poster Session 2 (P2)

Monday, June 25, 2018

Table 1. Components of the 32-point TEE comprehensiveness score.

Score component	Total points	Definition
Left ventricle	4	One point each for mid-esophageal 4-chamber, 2-chamber, and long-axis views of the LV, as well as 3D full-volume acquisition.
Right ventricle	1	Mid-esophageal 4-chamber view of the RV.
Mitral valve	4	Views of the mitral valve from 2 different imaging planes, color Doppler interrogation, and 3D acquisition of mitral valve anatomy.
Aortic valve	4	Short-axis and long-axis views of the aortic valve, color Doppler interrogation, and 3D acquisition of aortic valve anatomy.
Tricuspid valve	3	Views of the tricuspid valve from 2 different imaging planes and color Doppler interrogation.
Pulmonic valve	2	View of the pulmonic valve anatomy and color Doppler interrogation.
Pulmonary artery	1	Long-axis view of the main pulmonary artery up to the bifurcation of the right and left pulmonary arteries.
Left atrial appendage	2	Views of the left atrial appendage in 2 different imaging planes.
Pulmonary veins	2	Pulsed-wave Doppler interrogation of a left-sided and a right-sided pulmonary vein.
Interatrial septum	2	Bicaval view of interatrial septal anatomy and color Doppler interrogation.
Pericardial space	1	Mid-esophageal 4-chamber view at adequate depth to evaluate the pericardial space for effusion.
Transgastric	3	Transgastric views of the LV in short-axis, the LV in long-axis, and the RV.
Aorta	3	View of the ascending aorta in short-axis and of the transverse and descending aorta.

LV = left ventricle, RV = right ventricle, 3D = three-dimensional.

Table 2. Results and characteristics pre- and post-intervention

	Overall	Pre	Post	p-value
Patient characteristics				
Age, years	62.8 ± 16.9	63.1 ± 17.1	62.2 ± 16.6	0.540
Male	149 (58.4)	115 (61.8)	34 (49.3)	0.071
BMI, kg/m^2	29.6 ± 7.5	29.5 ± 7.8	30.0 ± 6.7	0.505
MAP, mmHg	89.9 ± 17.5	89.2 ± 17.2	91.7 ± 18.0	0.286
Study characteristics				
Inpatient	119 (46.7)	86 (47.2)	33 (47.8)	0.821
PACU location	106 (41.6)	82 (44.1)	24 (34.8)	0.181
MAC anesthesia	127 (49.8)	91 (48.9)	36 (52.2)	0.645
LAA indication	105 (41.2)	81 (43.5)	24 (34.8)	0.206
Fellow involved	233 (91.4)	171 (91.9)	62 (89.9)	0.619
Time duration, mins.	25:21 ± 8:53	25:13 ± 9:08	25:39 ± 8:13	0.493
Number of clips	94.4 ± 35.4	90.5 ± 33.4	105.0 ± 38.6	0.015
Comprehensiveness score	26.3 ± 4.1	25.7 ± 4.2	28.1 ± 3.1	< 0.001

Values reported are mean ± SD or n (%). P-values calculated with the Mann-Whitney-Wilcoxon test for continuous variables and chi-square test for categorical variables.

BMI = body mass index, MAP = mean arterial pressure, PACU = post-anesthesia care unit, MAC = monitored anesthetic care, LAA = left atrial appendage.

Table 3. Baseline TEE comprehensiveness scores by study characteristic.

	n	Score	p-value
Inpatient status			
Inpatient	86	24.9 ± 5.2	0.193
Outpatient	100	26.3 ± 3.0	
Location			
Echo lab	58	26.1 ± 3.0	0.215
PACU	82	25.3 ± 4.7	
EP lab	25	26.4 ± 2.4	
ICU	19	25.7 ± 5.7	
Cath lab	2	16 ± 5.7	
Anesthesia			
Moderate sedation	57	25.9 ± 3.2	0.461
MAC	91	25.3 ± 4.7	
General	37	26.1 ± 4.4	
None	1	22	
Indication			
LAA	81	24.8 ± 4.6	0.005
Others	105	26.3 ± 3.9	

P-values calculated with Mann-Whitney-Wilcoxon test for 2 samples or Kruskal-Wallis test for ≥3 samples.

PACU = post-anesthesia care unit, EP = electrophysiology, ICU = intensive care unit, cath = cardiac catheterization, MAC = monitored anesthetic care, LAA = left atrial appendage, ASD = atrial septal defect.

P2-07

Incremental Prognostic Value of Novel Echocardiographic Markers of Aortic Regurgitation in Patients with Continuous Flow Left Ventricular Assist Devices

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Background: Aortic regurgitation (AR) is a potentially serious complication in patients with continuous flow left ventricular assist devices (LVAD) but quantification by echocardiography is difficult due to the continuous nature of AR. Novel parameters utilizing LVAD outflow Doppler have been proposed but the reproducibility and incremental value beyond traditional techniques is not yet defined. We compared LVAD outflow Doppler quantification of AR to the vena contracta method. **Methods:** Among 254 consecutive patients with LVADs implanted from February 2007 to March 2017, LVAD outflow systolic/diastolic Doppler velocity ratio (S/D ratio) and diastolic acceleration were measureable in 204 patients (80%). AR severity was determined by vena contracta according to ASE recommendations, measured during early diastole and compared with S/D ratio and diastolic acceleration methods. Pre-implant clinical characteristics and LVAD settings at discharge were recorded and the impact of de novo AR on a combined adverse clinical outcome of heart failure hospitalizations, ventricular arrhythmias, aortic valve operation and cardiac death determined by ROC analysis. **Results:** AR was considered none in 30 (15%), trivial/mild in 106 (52%) and moderate in 68 (33%). S/D ratio was lower and diastolic acceleration values higher in patients with moderate AR. Although differences in mean diastolic acceleration were statistically significant, there was significant overlap in diastolic acceleration values between moderate and <moderate AR groups (41.5 ± 28.5 cm/s^2 for no AR group, 34.1 ± 21.5 cm/s^2 for trivial/mild AR group, and 45.6 ± 28.0 cm/s^2 for moderate AR group; p = 0.011). Adverse clinical outcomes occurred more frequently in patients with moderate AR than trivial/mild AR (10 (9.4%) and 29 (27.9%) respectively, p = 0.003). For ROC curve analysis to determine risk of adverse clinical outcome, an S/D ratio ≤1.99 and diastolic acceleration ≥48.67 cm/s^2 were chosen as cut-off values based on 25th percentile and 75th percentiles respectively. The results of ROC curve analysis were not significant (S/D ratio, AUC 0.534, p = 0.558 and diastolic acceleration, AUC 0.517, p = 0.770). In contrast, a vena contracta ≥3.0 mm signifying moderate AR was significant (AUC 0.659, p = 0.007). **Conclusion:** Novel echocardiographic parameters using outflow Doppler images in LVAD patients correlate with more traditional measures of AR including vena contracta. However, novel parameters did not add incremental prognostic value beyond the vena contracta method to assess AR.

P2-08

Integration of the Pediatric Appropriate Use Criteria with Electronic Medical Records Ordering System as a Decision Support Tool

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Background: The pediatric Appropriate Use Criteria (AUC) is aimed at improving appropriate utilization of transthoracic echocardiography (TTE) for initial outpatient evaluation. We recently incorporated it into the electronic medical record (EMR) ordering system to improve clinician access to AUC. We sought to determine the effect of this integration on the overall appropriateness of TTEs and assess any change in variability among physicians. **Methods:** Data were retrospectively collected from patients (≤18 years) who had initial outpatient TTE ordered prior to release of AUC (Pre-AUC phase) from 4/1/14 to 09/28/14. Physicians who saw less than 10 patients during each phase were excluded. A single reviewer assigned AUC indications and corresponding ratings upon review of clinic records: Appropriate (A), May Be Appropriate (M), or Rarely Appropriate (R)] or „Unclassifiable" (U) if the indication was not available in the AUC document. The physicians underwent an educational intervention prior to integration of AUC with EMR. In the EMR phase (6/1/17 to 12/31/17), the clinic physician assigned the AUC indication at the time of ordering TTE. Appropriateness of TTE orders and physician variability between the 2 phases were compared. **Results:** Among the 3,227 patients seen by 22 physicians (1164 in pre-AUC phase and 2063 in EMR phase), there was a significant increase in the proportion of A, a decrease in R and U and no change in M (Table A). When comparing the median appropriateness ratings of physicians between the two phases, there was a trend towards improvement in A and decrease in R (Table B). However, there remained a wide range of appropriateness ratings among physicians. **Conclusion:** Integration of pediatric AUC with EMR was helpful in improving appropriateness of TTE orders by increasing the proportion of TTEs ordered for indications rated A and reducing those for R. It also decreased the proportion of indications that were unclassifiable. Future studies could explore the factors influencing physician variability, so that targeted interventions could be implemented to reduce it.

Poster Session 2 (P2)

Monday, June 25, 2018

Table A. Comparison of Appropriateness of TTE orders between Pre-AUC and EMR phase			
Appropriateness of TTE orders	**Pre-AUC Phase N = 1164**	**EMR Phase N = 2063**	**p-value**
Appropriate	908 (78.0%)	1707 (82.7%)	0.001
May Be Appropriate	101 (8.7%)	204 (9.9%)	0.259
Rarely Appropriate	90 (7.7%)	75 (3.6%)	<0.001
Unclassifiable	65 (5.6%)	77 (3.7%)	0.014
Table B. Comparison of Physician Appropriateness Ratings for TTE Orders			
Appropriateness of TTE orders	**Median (range)**	**Median (range)**	**p-value**
Appropriate	78.0% (62.9 – 93.5)	84.2% (72.2 – 97.1)	0.050
May Be Appropriate	8.3% (0.0 – 18.8)	9.6% (0.0 – 19.3)	0.843
Rarely Appropriate	5.4% (0.0 – 24.4)	3.1% (0.0 – 9.3)	0.058
Unclassifiable	4.2% (0.0 – 11.6)	3.0% (0.0 – 9.1)	0.091

P2-09

Quality Improvement for Evaluation of Left Ventricular Function Protocol Decreases Overall Error Rate Among Cardiac Sonographers

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Background: Echocardiography remains an important tool for the evaluation of left ventricular (LV) function over time in patients with cardiomyopathy and those who have received potentially cardiotoxic drugs. Our echocardiography laboratory uses a LV function protocol to standardize image acquisition and measurements. The aim of this project was to evaluate the sonographer adherence to the LV function protocol and the accuracy of sonographer measurements before and after an educational intervention. **Methods:** 14 sonographers participated in this quality improvement study over the third quarter of 2016 and first quarter of 2017. The study was structured following the improvement methodology of plan do study act (PDSA). Five LV function protocol studies from each sonographer (70 studies in total) were evaluated by a single experienced sonographer both before and after the intervention. Each study was evaluated for 29 components taking into account study completeness, image order, and measurement accuracy. Deviation from the imaging protocol or standard measurement practices was counted as an error. The percent error was calculated as a cumulative percentage of the 29-components evaluated. Based on the initial data collection an educational session was arranged where the baseline data was presented, the imaging protocol reviewed and areas for improvement were highlighted. After the educational session, a second review (70 studies) of LV functions was performed, and the improvement calculated. **Results:** The chart below demonstrates the percent error rate in quarter 3, 2016 as compared to quarter 1, 2017 featuring some of the more significant declines in error rate (Table 1). There was improvement after the educational session.

Table 1:

	2D LV FS%	LA Volume	MV A Vm	MV A Dur	LV S/D	RV TDI MPI	TV Inflow Dopper
Q4 2016	13%	15%	10%	19%	13%	23%	34%
Q1 2017	6.40%	4.80%	3.20%	4.80%	4.80%	12.90%	9.60%

LA = left atrial, LV = left ventricle, MV = mitral valve, A Vm = a-wave velocity, A Dur = A wave duration; S/D = systolic/diastolic, RV = right ventricle, TDI = Tissue Doppler Velocity, MPI = myocardial performance index, TV tricuspid valve

Conclusion: Quality improvement project using the PDSA cycle helped sonographers follow the LV function protocol and decreased error rate of LV function studies performed.

P2-10

Reducing Pediatric Sonographer Variability in Measurement of Non-Indexed Left Ventricular Mass: Quality Improvement by Implementation of a Focused Educational Intervention

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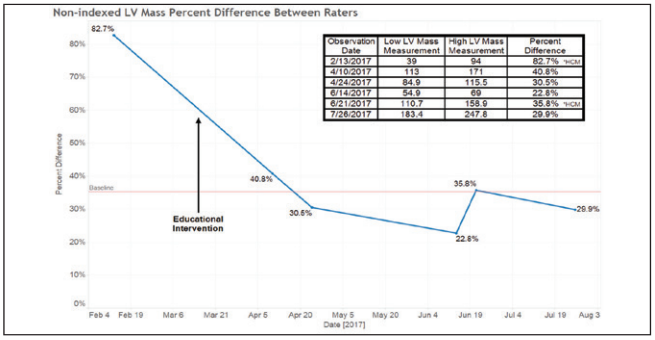
Background: Accurate and reproducible measurements of left ventricular mass (LVM) are critical for initial screening and serial follow up of patients at risk or with ventricular hypertrophy. Variability in performing these measurements can have a significant impact on clinical decision making. We sought to: 1) assess baseline inter-sonographer variability in non-indexed LVM measurement, and 2) determine whether implementation of a focused educational intervention would reduce variability. **Methods:** To determine baseline variability, fourteen sonographers at a large pediatric echocardiography laboratory independently and retrospectively performed baseline LVM measurements by M-mode in the parasternal short axis view at the level of the papillary muscles in a patient with hypertrophic cardiomyopathy (HCM). An educational intervention was provided by an echocardiography physician and measurement standards were set. This was followed by 3 biweekly practice and review sessions providing feedback in performing LVM measurements in normal patients after which repeat evaluation of inter-sonographer LVM variability was performed on the same HCM study and in a normal patient. **Results:** Initial inter-sonographer LVM variability was 82.7% for the patient with HCM and decreased to 35.8% after educational intervention. Inter-sonographer LVM variability in normal patients was 40.8% after intervention and continued to decrease (22.8%) with continued practice and review. This decrease in variability was sustainable over time, as noted by the final measurement of 29.9%.



Conclusions: A simple focused educational intervention with continued practice and feedback resulted in decreased inter-sonographer non-indexed LVM measurement variability, which was sustainable over time. This effort may be applied to other measurement standards, improving data quality which is critical to patient care and management.

P2-11

Serial Fetal Echocardiograms in Non-Hypoplastic Left Heart Syndrome Fetuses: Does it Affect Immediate Post-Natal Care

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Introduction: Guidelines recommend serial fetal echocardiograms when congenital heart disease is diagnosed. Necessity, timing, and frequency of serial echocardiograms are based on clinical judgment. Fetuses with single ventricle physiology (fSV), non-hypoplastic left heart syndrome, may undergo multiple studies prior to birth. Goal of this study was to determine if the need for unexpected, emergent cardiac procedures were identified on follow up studies, if there were no concerns on the initial fetal echocardiogram. **Methods:** All fetal echocardiograms performed between 2006 - 2014 on fSV were reviewed. fSV were excluded if the initial fetal scan documented an abnormal rhythm, pericardial effusion, obstruction at the atrial or pulmonary vein levels, or $\geq$ moderate ventricular dysfunction or atrioventricular valve regurgitation. Post-natal echocardiograms were compared to the initial fetal echocardiogram report. Unexpected, emergent catheterization or surgical procedures within the first 72 hours of life were recorded. **Results:** Total of 61 fSV studies were reviewed. Eight patients were excluded because of concerns on the initial fetal echocardiogram (5 had $\geq$ moderate regurgitation, 1 had $\geq$ moderate dysfunction, 1 had obstruction of the pulmonary veins, and 1 had 3rd degree heart block), thus 53 fSV were analyzed (13 = heterotaxy, 11 = tricuspid atresia, 8 = double inlet left ventricle, 5 = pulmonary atresia/intact ventricular septum, 5 = double outlet right ventricle, 2 = unbalanced atrioventricular septal defect, 9 = other). Ten fSV had one scan (25.2 $\pm$ 4.7 weeks), 26 had two scans (29.8 $\pm$ 3.4 weeks), 13 had 3 scans (32.7 $\pm$ 2.6 weeks), 3 had four scans (33.8 $\pm$ 3.9 weeks), and 1 had 5 scans (33.29 weeks). One patient required emergent central shunt placement at birth due to an absent ductus, but the absence of the ductus was documented at the initial fetal echocardiogram. No patient underwent an unexpected, emergent catheterization or surgical procedure within the first 72 hours of life. **Conclusion:** No fSV underwent an unexpected, emergent catheterization or surgical procedure within the first 72 hours of life if the initial fetal echocardiogram had no significant concerns. Serial fetal echocardiograms may not be necessary to predict the need for an unexpected, emergent procedure. Larger studies are needed in the fSV population to determine the cost effectiveness of serial fetal echocardiograms if the initial scan had no significant concerns.

Poster Session 2 (P2)

Monday, June 25, 2018

P2-12

An Electronic Medical Record Intervention Reduces Inappropriate Transthoracic Echocardiogram Orders

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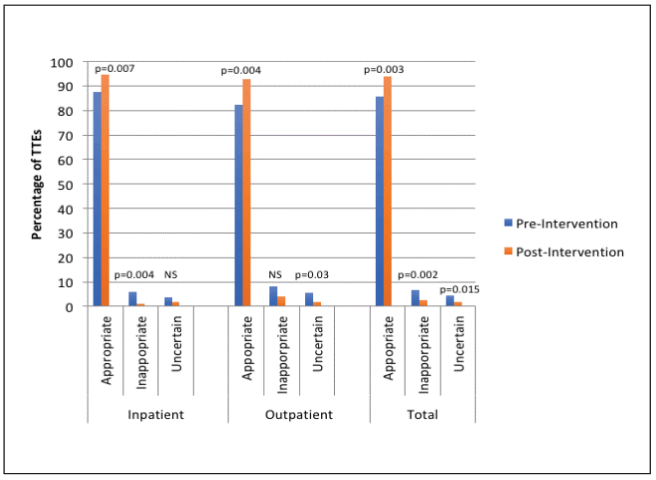
Background: Transthoracic echocardiogram (TTE) use in the US is increasing at an estimated rate of 6-8% per year. Appropriate use criteria (AUC) for echocardiography have been developed in an effort to reduce inappropriate TTE utilization, though encouraging providers to consult AUC in clinical practice remains challenging. We developed an electronic medical record (EMR)-based decision-support tool for TTE ordering and examined its effects on appropriateness of TTE orders. **Methods:** This prospective study was performed at the Veterans Affairs Ann Arbor Healthcare System. Consecutive TTEs ordered in inpatient, outpatient, and emergency department settings between October and December 2016 were reviewed for appropriateness based on the 2011 AUC. A decision-support tool, requiring providers to answer questions regarding TTE indications and providing immediate feedback on TTE appropriateness, was then incorporated into the EMR. Chart review was performed for TTEs ordered between June and August 2017 to determine post-intervention appropriateness. TTEs ordered for research, compensation and pension, and interventional or procedural protocols were excluded, as were TTEs for which insufficient clinical data were available. Data were analyzed using 2-tailed t-tests. **Results:** We reviewed 572 pre-intervention and 552 post-intervention TTE orders, of which we excluded 56 and 12 orders, respectively. Appropriate TTE orders increased from 442/516 (85.6%) pre-intervention to 506/540 (93.7%) post-intervention (p=0.003). For inpatients, appropriate orders increased from 220/251 (87.6%) to 242/256 (94.5%) (p=0.007). For outpatients, appropriate orders increased from 195/237 (82.3%) to 250/270 (92.6%) (p <0.001). Overall, inappropriate TTE orders decreased from 34/516 (6.6%) to 14/540 (2.6%) (p=0.002). There was also a significant reduction in TTE orders with uncertain indications from 23/516 (4.5%) to 10/540 (1.9%) (p=0.015). **Conclusion:** Implementation of an EMR-based decision-support tool resulted in a significant increase in appropriate TTE orders and decrease in inappropriate TTE orders in both inpatient and outpatient settings. Further study is needed to evaluate the durability of these effects and the generalizability of these findings to other clinical settings.



P2-13

NASA and Pediatric Echo Errors: Echo QA is Not Rocket Science

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Background: A methodic approach to error assessment is important in pediatric echocardiography. At the Medical University of South Carolina (MUSC), quarterly echo quality assurance (QA) conferences are structured according to the Boston Children's taxonomy (BCH-T) (Benavidez, 2008). In contrast, our pediatric cardiology morbidity and mortality conference is organized according to the National Aeronautics and Space Administration (NASA) aviation model of "threat and error" (NASA-T) (Hickey, 2015). Our aim was to adopt a program-wide approach of error assessment and system improvement. **Methods:** We retrospectively reviewed reported echo QA cases at MUSC over two years (2/2016 through 2/2018) and applied both BCH-T and NASA-T models of error assessment. BCH-T categorizes errors by type (false negative, false positive, discrepant), severity (minor, moderate, severe, catastrophic), preventability (yes, no, possible), and cause. NASA-T distinguishes threats, errors, unintended states, and outcomes. Demographic data including patient age, sex, weight, and body surface area (BSA) was collected in addition to circumstantial variables. **Results:** For BCH-T case categorization, 76% (29/38) of errors were false negative, 24% (9/38) discrepant, and 0 false positive. Severity was 37% (14/38) minor, 53% (20/38) moderate, 8% (3/38) severe, and 0 catastrophic. Preventability was 58% (22/38) preventable, 42% (16/38) possible, and 0 not. One identifiable cause was found in 50% (19/38), and 50% had more than one cause. The most common cause was cognitive, followed by patient-related and procedural. Applying NASA-T, 34% (13/38) had one identifiable threat, 66% (25/38) more than one. Threats included patient-related factors (size, complex anatomy), inexperienced sonographer, and location. One primary error was established in 79% (30/38), while 21% (8/38) involved multiple errors. Echo contribution to system error chains was identified in 13% (5/38). On multivariable analysis, BSA was the only factor predictive for multiple errors (p<0.01). Unintended state involved factors including need for additional imaging, delay in diagnosis, or presence of a residual lesion. Outcome was determined to be minor in 42% (16/38), moderate in 53% (20/38), major in 3% (1/38), and catastrophic in 0 cases. **Conclusion:** In our experience, NASA-T provides an institutional framework for discussions of error assessment. We have found this beneficial for highlighting threats and system errors, including those specific to MUSC, identifying points for improvement, and evaluating for presence of error cycles.

P2-14

Impact of Clinician Engagement on Implementation of the Pediatric Echocardiography Appropriate Use Criteria

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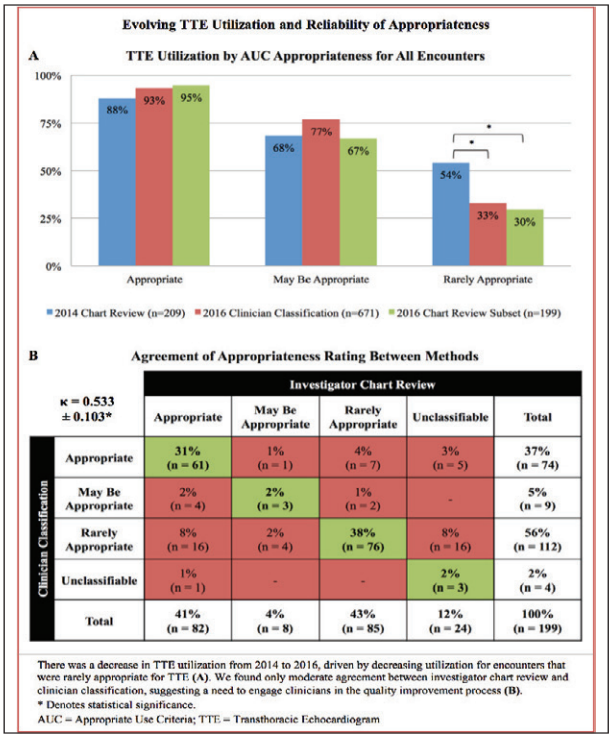
Background: We sought to determine whether awareness of the pediatric appropriate use criteria (AUC) affected transthoracic echocardiogram (TTE) ordering by cardiologists; evaluate for differences in classification of an encounter's AUC clinical scenario by investigator chart review compared with clinicians at the time of the encounter; and assess TTE yield by appropriateness rating. **Methods:** AUC clinical scenario(s) were assigned to patients without prior TTE by investigator chart review of visits in 2014 (n=209) and 2016 (n=199), and by clinician classification in 2016 (n=671). Investigators documented TTE utilization and findings. **Results:** A reduction in TTE utilization from 54% to 33% (p<0.001) of "rarely appropriate" (R) encounters between 2014 and 2016, resulted in a decrease in overall TTE utilization from 73% to 55% of encounters (p<0.001). There was only moderate agreement of AUC appropriateness by investigator chart review and clinician classification (κ = 0.533, p<0.001). Abnormal TTE findings were detected in 18.7% of R encounters, with 21 of 24 abnormalities being in infants younger than 4 months presenting with murmur. **Conclusions:** An overall decrease in TTE utilization for R encounters may represent a change in practice from increased awareness of the AUC. AUC scenario classification by clinicians at the time of the encounter could be superior to chart review. TTE abnormalities may be missed in infants 4 months of age or younger when evaluated for murmurs with the AUC.



Poster Session 2 (P2)

Monday, June 25, 2018

P2-15

A Comparative Analysis of British and American Society of Echocardiography Recommendations for the Assessment of Left Ventricular Diastolic Function

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Background: The echocardiographic assessment of left ventricular diastolic function (LVDF) remains challenging. At present there are two recognised guidelines provided by the British Society of Echocardiography (BSE) and American Society of Echocardiography/European Association of Cardiovascular Imaging (ASE/EACVI). However, to date no direct comparison of these guidelines has been performed to establish whether they provide similar diastolic grading. **Method:** Three hundred and thirty two patients in sinus rhythm were extracted from our echo database (McKesson Cardiology). Eighty seven *(26%)* patients were excluded due to left bundle branch block (2.1%), no indexed left atrial volume (18.2%) and annular calcification (5.7%). For each patient, LVDF assessment was performed using both guidelines and the results compared. Chi-square, Spearman correlation and Kappa score statistical tests were used to evaluate the data at a level of p <0.05. **Results:** The most frequent outcome was unclassifiable LVDF with significantly more patients being labelled unclassified by BSE (ASE/EACVI 43.7% vs. BSE 55.5%, p<0.0001). Having excluded unclassifiable patients, no difference was observed between the two schemes (p=.422) with substantial agreement when differentiating between normal and abnormal diastolic function (k=.694, p<0.0001). Where there was disagreement between the two guidelines, (normal LVDF by one and abnormal by the other), the degree of LVDF was never more than grade I. When grading subcategories were individually compared there was moderate agreement between the two guidelines (k=.581, p<0.0001). Significant correlations were seen between LV impairment (r=0.55, p<0.0001), indexed LA volume (r=0.43, p=0.001), E/e' (r=0.72, p<0.0001), tricuspid velocity (r=0.32, p=0.030) and ASE/EACVI grading. Similar correlations were seen between E/E' (r = 0.71, p<0.0001), Indexed LA volume (r=0.43, p<0.0001) and BSE diastolic grading. When comparing mean time taken to complete each algorithm, the ASE guidelines were marginally quicker to perform (ASE = 28sec vs. BSE = 36sec; p<0.0001). **Conclusion:** In around 50% of patients it was not possible to grade LVDF by either guideline. For those patients where grading was possible, there was no significant difference between BSE and ASE/EACVI guidelines with substantial agreement between each scheme when diagnosing normal or abnormal diastolic function and moderate agreement when comparing each LVDF subcategory. There was a small but significant reduction in time taken to complete the ASE algorithm when compared to the BSE diastolic guidelines.

P2-16

Validation of a Simulation-Based Tool For Formative Assessment of Echocardiography Skill Competence in Cardiology Trainees

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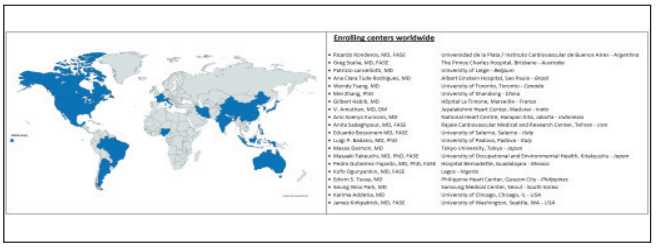
Background: New CoCATS4 guidelines for echocardiography training endorsed by the American Society of Echocardiography recommend assessment of core competencies using simulation, direct observation and multisource evaluation. We developed a novel, simulation-based echocardiography competence assessment tool (ECAT) of basic echocardiography skills. We then collected validity evidence to evaluate our claims that the ECAT can be used for formative assessment. **Methods:** We conducted a mixed methods pilot of cardiology trainees (n=5 PGY4; n=5 PGY5; n=4 PGY 6), who were oriented to the simulator, and assessed using the ECAT. We video-recorded performance and collected participants' simulated echocardiogram videos, which were assessed by four raters in real-time or off-line. After providing participants with video footage and rater feedback, we interviewed both participants and raters. For implications evidence, we used a simple content analysis to analyze interview data. For scoring evidence, we computed internal consistency, and inter-rater reliability metrics. For extrapolation evidence, we correlated ECAT scores with participants' expertise, diagnostic scan quality, and a summative exam score. **Results:** Our analysis of the interview data revealed three themes: i) feedback stimulated change, ii) how feedback was delivered impacted trainees' perceived learning, and iii) assessment credibility influenced trainees' reception of feedback. For scoring evidence, the inter-rater reliability was ICC=0.56, and an exploratory factor analysis demonstrated a two-factor model, for which Cronbach's alphas were 0.96 and 0.87 respectively. For extrapolation evidence, ECAT scores correlated with summative exam scores (r=0.66, p=0.02), and were positively associated with level of training (p=0.006), previous echocardiography experience (p=0.01), and diagnostic scan quality (p=0.0006). **Conclusions:** Trainees and raters provided specific data for refining the ECAT process, feedback delivery, and technology for improved formative assessment. We suggest the evidence for scoring and extrapolation are favorable, supporting use of the ECAT in a simulation-based formative assessment. Our study provides practical insights for echocardiography educators and those seeking to develop instruments for formative assessment.

P2-17

Rationale and Design of the World Alliance of Societies of Echocardiography (WASE) Normal Values Study

Tatsuya Miyoshi[1], Diego Medvedofsky[1], Karima Addetia[2], Jose Banchs[3], Rhonda Price[4], Vera H. Rigolin[5], James D. Thomas[5], Neil J. Weissman[1], Roberto M. Lang[2], Federico M. Asch[1]. [1]Medstar Health Research Institute, Washington, DC; [2]University of Chicago, Chicago, IL; [3]MD Anderson Cancer Center, Houston, TX; [4]American Society of Echocardiography, Durham, NC; [5]Northwestern Medicine, Chicago, IL

Background: Determination of normal echocardiographic values is necessary for the diagnosis of pathological conditions. Differences in chamber size and function are expected across different countries, geographical regions and cultures. Current normative values have been predominantly obtained from Caucasian North American and European populations and therefore may not be representative of the chamber size and function from other races, ethnicities or countries. ASE in collaboration with its International Alliance Partners is leading a study to establish and compare normal values worldwide for cardiac chamber quantification, including size and function by 2- and 3-dimensional echocardiography (2DE, 3DE). In this report, we describe the methodology of the WASE normal values study. **Methods:** WASE study is a worldwide prospective, observational, cross-sectional study. A total of 2000 adult individuals free from known cardiac, lung and renal disease are being prospectively enrolled at 20 centers in 17 countries. Each center will enroll 100 individuals evenly distributed among age groups and gender. Basic demographic information collected includes age, gender, height, weight, blood pressure, race, ethnicity and nationality. 2DE and 3DE are acquired following a standardized acquisition protocol that strictly follows ASE guidelines. All studies are being quantitatively analyzed (TOMTEC) at two echocardiographic core laboratories in the United States (MedStar and University of Chicago). **Results:** As of February 1st, 2018, 988 individuals have been enrolled. Regional principal investigators and their enrolling centers are shown in the Figure. Three countries have already completed enrollment: China, Iran and South Korea. An additional eight countries have enrolled over 50 subjects each. Enrollment is expected to be completed during 2018 with final results to be available in 2019. **Conclusions:** Normal reference values in conventional and advanced echocardiographic parameters across a wide range of ages, different races, ethnicities and countries will be available, which will enable the characterization of the similarities and differences among diverse populations worldwide.



P2-18

Automated Protocols Improve Workflow in Transesophageal Echocardiography

Peter Flueckiger[1], Arati Gurung[2], Rachel Kaplan[1], Ashley Brogan[1], Roy Arjoon[1], Robert McNamara[1], Ben Lin[1], Lissa Sugeng[1]. [1]Yale School of Medicine, New Haven, CT; [2]Siemens Healthineers, Malvern, PA

Background: Intersocietal Accreditation Commission (IAC) mandates use of specific and appropriate image acquisition for transesophageal echocardiography (TEE) studies. We hypothesized that an automated TEE imaging protocol improves study efficiency and workflow compared with a manual protocol. **Methods:** Protocols for three TEE indications (transcatheter aortic valve replacement (TAVR), mitral regurgitation (MR), and atrial fibrillation (AFib)) at a large academic echocardiography lab were used. Image acquisition was done twice for each TEE, once each using a manual and automated method in random order. The same sonographer assisted every acquisition with each operator (novice, <3 years experience, n=3; expert, ≥ 3 years experience, n=2). TEE exam duration (defined by timestamp on first and last image) was acquired and number of sonographer keystrokes for each method were counted. Keystrokes were grouped into categories (Fig 1e). Multivariate analysis of variance was performed for each variable. eSie Protocol on the Siemens SC2000 (Mountain View, CA) was used for all TEE exams. **Results:** 22 patients, 14 males, ages 31-83 years, average BMI 28.8 kg/m^2 (S.D.+/-6.3) were included in analysis. 44 TEE image protocols were acquired (22 manual and 22 automated comprised of 4 TAVR, 22 MR, and 18 AFib protocols). eSie TEE protocols significantly reduced the TEE exam duration regardless of operator experience level (Fig. 1A). The protocol performed secondly after randomization was shorter regardless of protocol method; however, the percentage decrease in duration of the second exam was significantly greater when the automated protocol was done secondly (Fig 1B). The eSie protocol required less number of sonographer keystrokes than manual protocol, regardless of experience level (Fig. 1C) or the protocol order (Fig 1D). Automated protocols required significantly fewer number

of angle corrections, gain adjustments, 2D optimizations, imaging plane navigations and miscellaneous keystrokes. Image capture (representing total images acquired) was similar between automated and manual protocols. (Fig. 1E) **Conclusion:** Automated protocols improve TEE efficiency by reducing the study duration and sonographer keystrokes regardless of TEE experience and without a difference in total number of TEE images acquired.

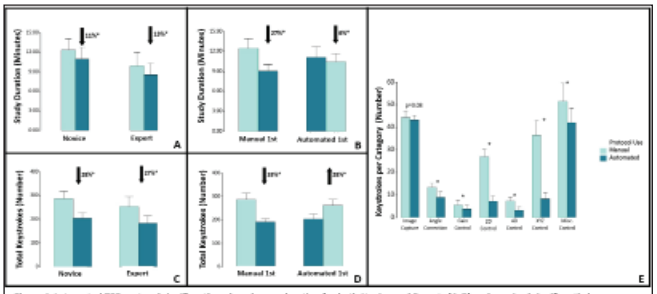


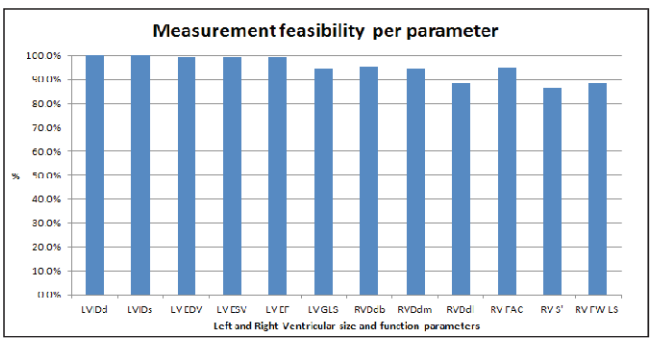
Figure 1 Automated TEE protocol significantly reduced exam duration for both Novice and Experts (A-B) and required significantly less sonographer keystrokes (while obtaining similar number of TEE images) (C-D); Comparison of the reduction of sonographer keystrokes based on categories (E). (* = p<0.05)

P2-19

2D Echocardiographic Measurements Feasibility for Left and Right Ventricular Size and Function in the World Alliance of Societies of Echocardiography (WASE) Normal Values Study

Tatsuya Miyoshi[1], Diego Medvedofsky[1], Seung Woo Park[2], Anita Sadeghpour[3], Mei Zhang[4], Karima Addetia[5], Rhonda Price[6], Neil J. Weissman[1], Roberto M. Lang[5], Federico M. Asch[1]. [1]Medstar Health Research Institute, Washington, DC; [2]Samsung Medical Center, Seoul, Republic of Korea; [3]Rajaie Cardiovascular Medical and Research Center, Echocardiography Research Center, Tehran, Islamic Republic of Iran; [4]University of Shandong, Shandong, China; [5]University of Chicago, Chicago, IL; [6]American Society of Echocardiography, Durham, NC

Background: Echocardiography is the imaging technique most frequently used for cardiac chamber size and function quantification. Full protocol acquisition and image quality determine 2-dimensional echocardiography (2DE) feasibility. Heterogeneity in image quality frequently affect multicenter clinical trials and clinical management and is mostly related to patient's characteristics and sonographer's technical skills. We aimed to assess 2DE measurements feasibility for left and right ventricular (LV, RV) size and function in the World Alliance of Societies of Echocardiography (WASE) normal values study. **Methods:** WASE study is an ongoing worldwide prospective, observational, cross-sectional study. Individuals free from known significant cardiac, lung and renal disease are being prospectively enrolled in 17 countries. 2DE images are acquired following a standardized protocol and training and analyzed by a Core lab following ASE Guidelines. LV measurements include: dimensions, volumes, biplane ejection fraction (EF) and global longitudinal strain (LS). RV measurements include: end-diastolic dimensions of base, mid and length (RVDdb, RVDdm, RVDdl), fractional area change (FAC), tissue Doppler imaging (TDI) derived tricuspid annular systolic velocity (S') and free-wall (FW) LS. Parameter feasibility is presented as percentage (measured /total cases analyzed x 100). All cases from the 3 countries that have completed enrollment are included. On a per-echo basis, poor quality was considered when < 60% of variables were measurable, good when 60-85% and excellent when > 85%. **Results:** As of January 2018, 310 2DE studies have been analyzed. LV dimensions were feasible in 100%, volumes and EF in 99%, while global LS in 95%. RV dimensions and FAC were feasible in 95%, S' in 86% and FW LS in 88%. Feasibility for each parameter was similar in all countries. Overall, 4.8% echoes were of poor quality, 3.6% were good and 91.6% excellent. **Conclusions:** Feasibility of measuring 2DE LV and RV size and systolic function parameters in the WASE normal values study is high. Overall, the image quality is excellent. Complete protocol acquisition and high image quality will allow the performance of this worldwide study, which has the potential to describe normal reference values in different races, ethnicities and countries.



P2-20

Inpatient Echocardiography Use and Hospital Outcomes in Acute Myocardial Infarction

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Background: The impact of echocardiography (echo) on outcomes among hospitalized patients with acute myocardial infarction (AMI) is poorly understood. **Methods:** Using data from a large consortium of US hospitals from 2014, we examined the association between hospital rates of transthoracic echo use and inpatient mortality, hospital length of stay, hospital costs, and 3-month readmission. First, we calculated risk-standardized echo rates for hospitals treating patients with AMI. Then, using multivariable hierarchical modeling, we evaluated associations between quartiles of hospital risk-standardized echo rates and patient outcomes. **Results:** We included 98,999 admissions from 397 hospitals, of which 69,652 (70.4%) had a transthoracic echo performed during the hospitalization. The median (IQR) risk standardized rate of echo was 72.5% (62.6% to 79.1%). In adjusted models that included multiple hospital characteristics, treatments, and patient demographics, we found no difference in inpatient mortality [OR 95% CI, 1.02 (0.88 to 1.19)], or 3-month readmission [OR, 95% CI, 1.01 (0.93 to 1.10)] between high use (top quartile) and low use (bottom quartile) hospitals. However, hospitals with the highest rates of echo had a modestly higher length of stay [+0.23 days (95% CI: 0.04 - 0.41), p = 0.01] and higher costs, $3,164 (95% CI, $1843 - $4485), p <0.001 per admission compared to hospitals in the lowest quartile of use. **Conclusions:** Higher hospital rates of echo were associated with greater hospital costs but without concomitant improvements in clinical outcomes. These findings suggest that a more selective approach to the use of echo than is currently recommended in guidelines may be warranted among patients with AMI.

P2-21

Impediments to Contrast Use in Echocardiography in Connecticut

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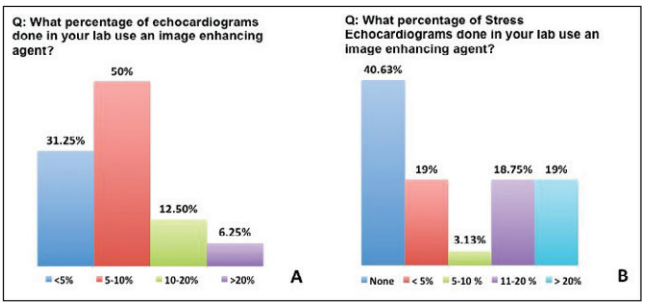
Background: Contrast echocardiography (CE) improves endocardial border delineation for wall motion assessment and left ventricular function and visualization of left ventricular thrombus; however, it is not widely used. Our aim was to evaluate current contrast practices and understand factors limiting its usage in echocardiography laboratories in Connecticut (CT). **Methods:** An online questionnaire comprising 30 questions was designed using a web based survey tool (Qualtrics). With an attempt to cover both physician and sonographer perspectives, the survey was sent to 33 echocardiography laboratories (private and academic) throughout CT. **Results:** Of the 72 surveys sent, 32 responded from community hospitals, private offices, academic hospitals and academic outpatient offices (41%, 28%, 28% and 19% respectively). There was equal representation of sonographers and physicians. Although all labs use contrast agents, 80% of the respondents use it for less than 10% of the echocardiograms (Figure A). For stress echocardiography, 59% of the labs use contrast, of which two-thirds use it for <20% of their studies and one-third for >20% (Figure B). Most sonographers (97%) make the decision to use contrast during a study. Most labs (81%) do not have a sonographer trained to gain intravenous (IV) access, but 70% would like sonographers to be able to inject an agent. The greatest impediment to contrast imaging is inadequate nursing staff support (85%), of which 78% think that the usage would increase if they had nursing support. Another impediment was that CE added additional time to the study with already inadequate time allocation for individual studies. More than two-thirds of the labs seem to have a strategy around increasing the use of contrast agents by 1) Training nurses on contrast administration, 2) Training sonographers to get IV access and injecting contrast and 3) Implementing policy changes that allow sonographers to inject. Of note, the most common method of LV ejection fraction assessment is visual estimation (52%), followed by biplane Simpson's method (37%), while three-dimensional assessment is rarely used (4%). **Conclusion:** CE usage is still low in CT. Additional nursing support, training sonographers to obtain IV access and policies to allow sonographers to inject contrast would improve contrast usage.



Poster Session 2 (P2)

Monday, June 25, 2018

P2-22

Feasibility and Effectiveness of the Machine Based Built-in Protocol for Echocardiographic Evaluation of Patients with Heart Failure and/or Cardiomyopathy

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Background: Specific written protocols for imaging cardiac patients are typically maintained in echocardiography (echo) laboratories to guide sonographers. But it is not a common practice to have the protocol available at bedside during an exam which could lead to diagnostic error owing to inadequate study. A machine-based built-in protocol (MBP) eliminates the need for sonographers to remember all the elements of written protocols and can improve the quality of the studies. The objective of this project is to assess the adequacy and efficiency of echo studies performed using such protocol for pediatric heart failure/cardiomyopathy (HF/CMP) patients. **Methods:** This study involves the review of echo data of patients presenting in the HF/CMP clinic who had their study performed with or without the MBP. The MBP was prepared by incorporating the elements of an existing written protocol for evaluation of HF/CMP patients into the echo machine. Scores were assigned to each element of the protocol based on the adequacy of the images and/or measurements, and were added to give a composite score. The composite score was then expressed as a percentage of the maximum possible score. The studies with a percentage score >90% were considered adequate. Studies performed with and without the MBPs were compared for adequacy and duration of study using non-parametric tests (JMP software). **Results:** Table 1 demonstrates the comparison between the studies performed with and without the MPB. The studies performed with MBP had higher composite score (a measure of adequacy) and higher proportion of adequate studies (as defined above) compared to those performed without the protocol (Table 1). Time required to complete an echocardiogram was similar in both categories however the total number of images obtained were lower in studies performed with MBP (Table 1). **Conclusion:** Built-in machine based echo protocol is feasible to use and can improve the quality of echo studies for evaluation of HF/CMP by improving the adequacy. The protocol also proves to be equally efficient compared to the conventional practice of imaging which is dependent on sonographer's recollection of written protocols. Built-in protocol also reduces the number of images acquired in an echo study by dictating the specific elements needed for evaluating a patient with HF/CMP.

Table 1 Comparison of studies with and without MBP

Variables	Without MBP	With MBP	P-value
N	32	14	
Composite Score	76.5 (12.7)	96.3 (6.4)	<0.0001
% of adequate studies	9.38%	92.86%	<0.0001
Duration of study (min)	32.2 (21.6)	31.1 (8.25)	0.4306
Total number of images	80.7 (16)	58 (4.2)	<0.0001

P2-23

Implementation of Sonographer Driven Organizational Goals Improves Study Completeness and Image Quality in the Pediatric Echo Lab

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Background: Quality improvement (QI) in the pediatric echocardiography (echo) laboratory is an ongoing process that requires group engagement. However, hospital organizational goals for staff may not align with echo specific QI efforts, thus detracting from the QI process. To overcome this barrier, we created echo QI related organizational goals to improve our lab's study completeness (SC) and image quality (IQ). Our goal was to demonstrate improved SC and IQ at one year after initiation of organizational goal driven QI intervention. **Methods:** Study Completeness Score (SCS) was graded on a scale of 1-5 starting in July 2015. SCS of 1-3 were considered incomplete and 4-5 considered complete. A senior sonographer retrospectively scored 70-100 randomly selected transthoracic echos billed as complete at each time point. Six months of data were collected prior to intervention (time point 1). The intervention consisted of lectures on the complete protocol, reminder signs placed on each machine, and individual feedback. Eighteen months of data divided into six month blocks (time points 2, 3, and 4) were collected after the initial intervention. Image quality score (IQS) was graded on a 1-5 scale starting in July 2016. IQS of 1-2 were considered unacceptable quality and 3-5 considered acceptable. Six months of data were collected prior to intervention (time point 1). Intervention for IQ included lectures on IQ improvement and physics, and individual feedback. Twelve months of data divided into six month blocks (time points 2 and 3) were collected after the initial intervention. Monthly reviews of IQS and SCS at sonographer meetings and individual feedback have continued. **Results:** SCS was measured on 342 total echos. There were 75% incomplete studies at time point 1, and improved to 49%, 13% and 6% at time points 2-4, respectively. Changes between time points were all statistically significant ($p < 0.001$) except between points 3 and 4 ($p = 0.302$). IQS was measured on 220 total echos. There were 32% unacceptable studies at time point 1, and improved to 24% and 9% at time points 2 and 3, respectively. The difference between time point 1 and 2 was not significant ($p = 0.597$), but the difference between time point 1 and 3 was significant ($p = 0.004$). **Conclusion:** QI efforts aligned with work related organizational goals can improve SC and IQ in the pediatric echo laboratory. SCS showed immediate and consistent improvement up to 18 months. Improvement in IQS was not seen in the 6 months after initial intervention, however, with continued monthly education, improvement is IQS was noted in months 6-12 after the initial intervention.

P2-24

Implementing a Novel Physician Echo Interpretation Quality Metric

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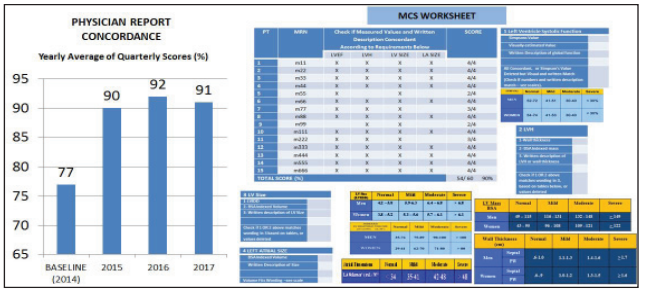
Background: Objectively measuring physician echo interpretation quality is challenging, and we found Intersocietal Accreditation Commission (IAC) certification inadequate to maintain physician performance. As a measure of physician interpretation quality, we developed and applied the Measurement-Concordance Score (MCS). **Methods:** Between July 2015 and Dec 2017, we randomly selected 15 transthoracic echo studies for review on a quarterly basis from our laboratory. The completed report is reviewed for physician statements of: (1) Left Ventricular Ejection Fraction (LVEF), (2) Left Ventricular (LV) size, (3) LV mass/wall thickness, and (4) Left Atrial (LA) size. The MCS quality metric requires that the report written descriptor (normal, mild, moderate, severe) for each of these 4 parameters must be concordant with the sonographer measurements, based on scales from the most recent ASE Chamber quantification guidelines. If there is concordance between the measured value and the report descriptor, the physician is awarded a point. The maximal number of points for each report is 4. The quarterly maximal points that can be achieved from 15 reports is 60. Flip charts containing the guideline scales were placed at each echo reading station. Physicians are provided group feedback, as well as individual performance scores at quarterly IAC meetings. We established our baseline performance of the MCS metric prior to initiating this program by randomly selecting 15 studies for review from July 2014. **Results:** Prior to beginning this program with physicians, our baseline MCS was 77%. We chose 90% as our goal for this metric. Through the process of quarterly MCS measurement and performance feedback to physicians, we were able to maintain the MCS at 90% or above since starting this program. **Conclusions:** The quality of physician echo interpretation is challenging to objectively measure. Confirming physicians are reviewing key sonographer measurements and correctly incorporating them into reports is one approach to assessing physician quality. By implementing a time efficient scoring system that provides regular feedback to physicians, we were able to improve the accuracy and consistency in our laboratory's reporting of LVEF, LV size, LV mass/wall thickness, and LA size.



P2-25

Development and Implementation of a Comprehensive Curriculum for Pediatric Echocardiography Boot Camp

Tania L. Saroli, Nazia Husain, Peter Koenig. Ann and Robert H. Lurie Children's Hospital, Chicago, IL

Background: Given the time constraints of fellowship training with an increasing base of required knowledge, and decreased training time due to duty hours restrictions, training methods resulting in increased training efficiency are desirable. Cardiology and echocardiography-specific "boot camps" are not new to training, but can be refined. Using Kern's theory for curriculum development in medical education, and implementing various educational techniques, we hypothesized that novice first year Pediatric Cardiology fellows could be trained to perform a complete echocardiography scanning protocol in a shorter time than prior years and have a superior knowledge base at the completion of the boot camp. **Methods:** A comprehensive echocardiography boot camp was redesigned to include pre-boot camp reading material, simulation sessions, didactic lectures, practice testing, flashcards, reverse classroom sessions, and 3D print modeling. Simulation training included review of practical scanning techniques, imaging planes, and clinical cases. An evaluation process consisted of pre- and post-session knowledge assessments, as well as final competency testing to assess performance of a complete scanning protocol on a model patient. A knowledge assessment quiz was also administered to current fellows who did not undergo the revised boot camp experience for comparison. **Results:** At the conclusion of boot camp, all three novice Pediatric Cardiology fellows passed the proctored competency test, and were able to scan a full complete echo study protocol. In addition, they increased their mean score on the knowledge assessment quiz from pre- to

post-boot camp from 76.4 to 83.8% (a 7.4 % increase). Their post-boot camp knowledge assessment scores were higher than categorical fellows entering their second fellowship year (83.8% vs 79.9%), and were closer to those entering third year (86.8%). Faculty evaluations at 6-month post boot camp have shown superior imaging performance of the first year fellows, with a perceived reduction in the need for sonographer back-up on call compared to prior year. **Conclusion:** The development of a comprehensive curriculum-based boot camp using multiple educational strategies resulted in superior performance of novice first year categorical fellows compared to those who did not undergo the boot camp the year prior. In terms of imaging skills, there was a marked decrease in time needed to achieve the performance of a full complete scan per standard protocol. There was an increase in knowledge to a level comparable to current fellows in more advanced stages of training.

P2-26

Echocardiographic Detection of LVAD Malfunction using Outflow Cannula Velocity Measurements: Does Device Type Matter?

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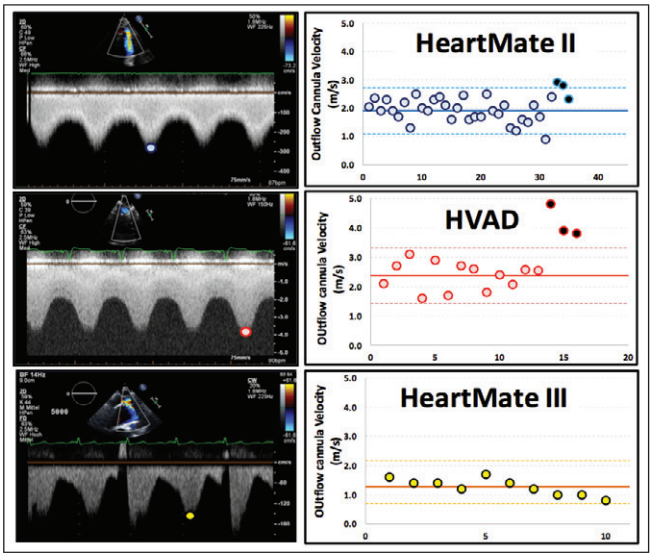
Background: Echocardiographic assessment of the left ventricular assist device (LVAD) includes Doppler interrogation of the outflow cannula (OTC) to screen for malfunction. The OTC is anastomosed to the ascending aorta and conducts blood from the LVAD pump to the systemic aorta. Elevated Doppler echocardiography-derived peak flow velocity in the OTC can signal obstructed flow or cannula malposition. Recently, a new LVAD (HeartMate (HM) III) has been FDA approved. There are no cut-off values to identify abnormally high OTC velocities in this type of LVAD. We sought to establish the normal range for OTC velocities for the HMIII and compare them with those for the HMII and HeartWare (HVAD). **Methods:** 61 patients with LVADs (HMII=35; HVAD=16; HMIII=10) underwent transthoracic echocardiograms (TTE) with OTC assessment from the right parasternal approach. Continuous wave (CW) Doppler peak velocity of the LVAD OTC was measured. Of the 61, 55 had normally functioning LVADs and were used to generate the normal range of OTC velocity (defined as ± 2SD around the mean). **Results:** Mean OTC peak velocity was 1.9±0.4 m/s (HMII), 2.4±0,5m/s (HVAD) and 1.3±0.3m/s (HMIII) with upper reference limits of 2.7m/s (HMII), 3.3 m/s (HVAD) and 1.8m/s (HMIII). OTC velocities were significantly different between LVAD types ($p<0.01$). Five patients had peak OTC velocities above the respective reference limits (Figure, black dots). OTC malfunction was confirmed in all these patients: Two (HMII) had a visible "kink" on CT scan, two (HVAD) had OTC narrowing and 1 (HVAD) had OTC thrombosis. One patient with a HMII had OTC velocity within the reference range (2.3 m/s) but was diagnosed with OTC malfunction. On cardiac catheterization this patient had 50% OTC stenosis. **Conclusions:** In our cohort of patients with normally functioning LVADs mean OTC velocities were highest in HVAD>HMII>HMIII. This data suggests that a single reference limit may not be applicable to all LVAD devices. In order to diagnose OTC malfunction, the reference limits of the specific LVAD type should be used.



P2-27

Hospitalist Use of Point-Of-Care Cardiac Ultrasound in an Expert-Collaborative Model: Demonstration of Accuracy and Fiscal Viability in an Internal Medicine Residency

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Background: Although point-of-care ultrasound(POCUS) may improve initial diagnosis of the acutely-ill medical patient, barriers to its use include integration, training and cost. Using trained residents, we sought to observe the frequency, accuracy, and financial impact of cardiac POCUS by an admitting physician carrying a convenient pocket-sized device(PSD). **Methods:** At a 300-bed hospital, we teach and monitor the use of POCUS as a part of internal medicine residency, which afforded the observation of use of PSDs provided to consecutive residents during a hospitalist rotation from convenience-sampled shifts (n=1200 admissions). All residents (n=48) had previously undergone 1-year of training in cardiac limited ultrasound examination (CLUE) and imaged patients at their own discretion during the rotation. In an accuracy substudy of 21 consecutive residents performing 252 CLUEs, a cardiologist used a PSD to re-image patients who had undergone imaging by the resident. The self-reported results of the residents were compared to the cardiologist's gold-standard for CLUE signs (LV dysfunction, left atrial enlargement, lung comets and effusions, and elevated CVP). To evaluate financial impact, the reimbursement for the professional component of limited echo was tracked after submission of consecutive cardiologist-CLUEs. Using the average volume from the usage database and average collection (in dollars) per CLUE from the billing data, we projected overall monthly return for a "shared" device, assuming a hand-off model between 3 hospitalists with 24h continual coverage. **Results:** In the usage database, over the 285 eight-hour shifts sampled, 48 residents performed 485 CLUEs on 1200 admissions (4.8 admissions/shift; 1.9 CLUEs performed/shift) for a mean(±SD) usage of 40%±17%. Mean resident accuracy was 82%. Residents were most accurate (86%) at detecting LV dysfunction, and least accurate (78%) for elevated CVP. For the billing subanalysis, 141 patients were re-imaged by the cardiologist: 9 had no medical necessity, 132 claims were submitted and 122(91%) of those claims were paid. Overall average return was $23.84/CLUE application. Assuming a 15% billing overhead, a return of $3465/mo was projected for a shared device. **Conclusion:** Trained physicians in a hospitalist role often employ cardiac POCUS with sufficient accuracy and indication during medical admissions, using a pocket-sized device. With cardiologist collaboration, hospitalist POCUS could have diagnostic errors recognized, recoup remuneration that can offset training and equipment costs, and potentially improve patient care.

P2-28

Risk Factors, ECG and Small, Portable Echocardiography in Vietnam: A Report from ASE-Vietnam National Heart Institute Outreach Events

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Background: Small, portable echocardiography devices can improve access to diagnostic technology in resource poor settings, especially in lower and middle income countries that face growing incidence, morbidity and mortality from cardiovascular disease. **Methods:** Residents of three underserved health districts in rural Vietnam were invited to participate in a 1 day cardiovascular outreach, as part of routine village outreaches through the Vietnam National Heart Institute (VNHI), in 2015 and 2017. VNHI clinicians performed patient interviews, and blood pressure and ECG recordings, and ASE member sonographers (n=11) and one VNHI physician performed echocardiography with laptop sized devices (M7, Mindray Corp. Shenzhen, China and Vivid IQ and LOGIQ V2s, GE Healthcare, Boston, MA). Findings on echocardiography were pre-specified as clinically significant or otherwise. ASE member physicians (n=5) and VNHI physicians (n=1) immediately interpreted and transcribed findings that were made available to a Vietnamese physician consulting with the participants. **Results:** 653 participants were recruited at one site in Dong Anh district and two sites in Thanh Hoa province in northern Vietnam. Age of subjects ranged from 1 month, 20 days to 94 years, with 379 females (58%). Cardiac risk factors included smoking 85/632 (13.4%), family history of

heart disease 250/637 (39.2%), hypertension 277/635 (43.6%), diabetes 66/636 (10.4%). Blood pressure range was 68-203/45-130mmHg. There were 307/637 (48.2%) subjects with blood pressure readings >140/90mmHg, and 51/637 (8.0%) subjects with diabetes and blood pressure readings >130/80mmHg. In all subjects without cardiac risk factors (N=270), 104 (38.5%) had any echo findings, and 43 (15.9%) had significant echo findings. Among subjects >16 years of age and without cardiac risk factors (N = 125), 13 (10.4%) had significant findings, including severe mitral stenosis (N=1), congenital heart disease (ASD or VSD, N=4), and left ventricular systolic dysfunction (N=8). There were 583/653 subjects (89.3%) with normal ECGs. In this group, 262/583 (44.9%) had any echo findings and 110 (18.9%) had significant echo findings. **Conclusions:** Risk factors and ECG screening failed to identify many subjects with important cardiovascular diagnoses in rural, medically underserved areas. Echocardiography with small, portable machines detects clinically significant findings in this population and may prove beneficial as a standard component of medical outreaches to village health centers.

P2-29

Normative Growth Curves for Inferior Vena Cava and Abdominal Aorta

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Background: Diameter of inferior vena cava (IVC) is affected by patient age, size, hydration status and other factors affecting right atrial as well as abdominal pressure. The descending aorta, showing less capacitance compared to veins, is less affected by hydration status. Nomograms for these structures in pediatric population are limited. A study was performed to establish echocardiographic nomogram for aorta and IVC and describe correlation of aorta, IVC as well as IVC/Aorta ratio to height, weight, body surface area and patient age. These may then prove a reference in understanding increased right atrial filling pressures during childhood. **Methods:** Retrospective review of echocardiograms was performed on 360 children presenting to cardiology department between 2014 to 2016 and ranging 0 to 18 years in age. Exclusion criteria included history of congenital or acquired heart disease, abnormal echocardiogram, abnormal vital signs, pregnancy, reported symptoms of vomiting or diarrhea or any illness thought likely to influence volume status. Maximum IVC diameter was measured during quiet respiration in the sagittal plane distal to the hepatic vein- IVC junction. The maximum diameter of the infradiaphragmatic aorta was also measured in the sagittal plane. Data was collected from 20 patients at each age group cohort of 1-18 years. Patients with suboptimal imaging for measurements were excluded. The correlations between IVC diameter, aortic diameter and IVC/Aorta ratio as a function of age, height, weight and BSA were calculated using the Spearman rank correlation coefficient. **Results:** There was statistically significant positive correlation between age and the maximum diameter of IVC ($P < .01$). There was statistically significant correlation between age and aortic diameter ($P < .01$). IVC/aorta ratio does not increase linearly with age. **Conclusions:** Echocardiographic nomogram is developed for pediatric patients for aorta and IVC. Normative growth curves were developed for aorta and IVC by age, gender and body surface area. Further studies should include larger number of subjects for validation of these observation.

P2-30

Simulator Based Formative Assessment of Skill in Bedside Echo for Measuring the Learning Curve in Medical Students

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Background: Implementation of competence based medical education requires assessment of competence. We applied previously validated metrics of psychomotor (technical) and cognitive skill in transthoracic echo to assess the rate at which medical students learn bedside echo. **Methods:** Eighteen 1st and 2nd year students elected to take a self-paced, simulator-based course with integrated didactic and hands-on training. Didactic integration is a structured, stepwise approach to train on normal cases before introduction to pathology. The parasternal long axis, parasternal short axis at aortic valve, parasternal short axis at mitral valve, and apical 4 chamber views were taught and assessed. Students took simulator based tests at baseline (pre), after 7 cases (interim), and after 10 cases (post). Psychomotor (technical) skill is measured in terms of the angle error between an acquired image and the plane of the anatomically correct image for the view. Cognitive skill is judged from multiple choice questions on image interpretation. These metrics provided immediate feedback to students to inform them of their progress without requiring constant faculty oversight. Students see original patient images that morph in real time as the transducer moves on the mannequin. To assess the rate of learning the same case was repeatedly presented at pre, interim and post tests. To assess students' ability to apply their learning, the post test included a case that students had not scanned before. **Results:** The learning curve was faster for psychomotor than for cognitive skill. Psychomotor skill measured from the angle error averaged over all 4 views improved from 50 ± 25° (pre) to 21 ± 13° (interim, $p < 0.0001$ vs. pre) and remained at that level at post on both the repeated case (22 ± 15°) and the new case (23 ± 15°). Students' skill in image interpretation improved from 43 ± 41% (pre) to 79 ± 18% (interim, $p<0.005$ vs. pre) and 89 ± 21% (post, p = NS vs. interim) when tested on the same case. However the score on the new post case (67 ± 26%), although improved from pre ($p<0.05$), was significantly worse than the repeated case. **Conclusions:** This study describes the learning curve for both psychomotor and cognitive skill in diagnostic bedside echo. Medical students reached a plateau in image acquisition after scanning 7 cases, but image interpretation was still deficient after 10 cases. The simulator-based metrics described are useful for formative assessment of the efficacy of curricula and the progress of learners in an objective and quantitative manner.

P2-31

Arterial Plaque by Point-of-Care Vascular Ultrasound as a Bedside Imaging Biomarker to Predict Significant Coronary Artery Disease

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Background: Coronary artery disease (CAD) is the leading cause of death in North America. Angiography is the clinical standard for the diagnosis of CAD, but its invasive and costly nature precludes its use as a screening tool. Carotid plaque height and area, measured by ultrasound, have been shown to predict CAD. However, the cost of a formal carotid ultrasound examination has limited its use as a cardiac risk screening tool. We propose a rapid quantification of carotid plaque using hand-held vascular ultrasound as a point-of-care biomarker for cardiovascular risk-stratification. **Methods:** We performed a focused vascular carotid ultrasound in 133 patients referred for coronary angiography using hand-held (Vscan, GE Healthcare) and conventional (VividE9, GE Healthcare) ultrasound devices. Maximum plaque height (MPH) and total plaque area (TPA) of the carotid bulbs were measured using offline software (Figure 1). MPH measurements were also taken on the Vscan at the point-of-care. In a subset of 20 patients, inter-rater reliability was assessed. All procedures were conducted and interpreted by investigators blinded to the angiogram results. **Results:** Point-of-care and software-based measurements of MPH using the Vscan correlated well to conventional ultrasound ($r=0.85$, $p<0.0001$; $r=0.84$, $p<0.0001$). Similarly, Vscan measurements of TPA correlated well to conventional ultrasound ($r=0.94$, $p<0.0001$). MPH and TPA measured using Vscan software were increased in patients with significant CAD (≥50% stenosis) (2.9±0.8 mm vs. 2.2±0.8 mm, $p<0.001$; 71±60 mm^2 vs. 42±30 mm^2, $p=0.0002$). Point-of-care measurements of MPH were also increased in patients with significant CAD (2.8±0.8 mm vs. 2.2±0.7 mm, $p<0.0001$). The intraclass correlation coefficients for MPH and TPA by Vscan indicated good inter-rater reliability. **Conclusion:** This study demonstrates that a focused carotid ultrasound using a hand-held device has the potential to provide an expedited, accurate, and cost-effective point-of-care imaging biomarker for clinical risk stratification.

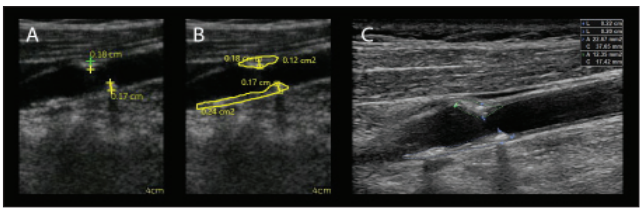

Figure 1 MPH and TPA using hand-held and conventional ultrasound systems. Measurements of A) MPH taken on the Vscan system at the point-of-care, B) MPH and TPA taken on Vscan offline software, and C) MPH and TPA taken using a conventional ultrasound offline software.

P2-32

Prognostic Value of Quick-Look Cardiac Ultrasound Signs: Evidence-Basis for a Simple Point-of-Care Exam to Refine Referral for Outpatient Echocardiography

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Background: Point-of-care ultrasound (POCUS) techniques can rapidly detect life-threatening disease, facilitate triage, and direct cost-effective downstream testing in emergency medicine. However, few outcome data exist in outpatient medicine that evaluate specific cardiac POCUS techniques, such as those that detect elevated cardiac filling pressures, for their ability to risk stratify patients and affect echo referral. Therefore, we examined standard outpatient echo studies for 2 "quick-look" ultrasound signs of left atrial enlargement and inferior vena cava plethora already contained therein, and whether these POCUS signs were associated with mortality. **Methods:** In a large healthcare system, we reviewed the initial echo studies, performed 5.5 years previously, and subsequent electronic health records of 240 consecutive outpatients for the presence of 2 nonquantitative signs recorded within each study's standard imaging protocol: LAE+, when the left atrium appeared larger than the overlying aorta in diastole in the parasternal long-axis view and, IVC+, when the IVC appeared dilated and its diameter did not vary 50% with inspiration in the subcostal view. Associations of LAE+, IVC+ and clinical variables (age, gender, coronary disease, hypertension, stroke, COPD, diabetes, renal failure, and whether the echo was referred by a cardiologist or noncardiologist)

with all-cause mortality were assessed in univariate and multivariable models. **Results:** Patient age was 61.9 (±17.4) years; 48.4% were female. The prevalence of LAE+, IVC+, and either sign were 43%, 10% and 46%, respectively. Mortality at 5.5 years was 14.6%, (35/240) overall, 23% in patients with LAE+ (OR 3.5 [1.6, 7.6]), 25% with IVC+(OR 2.2 [0.8, 6.0]), and 21% with either sign(OR 3.0 [1.4, 6.4]). In those lacking LAE+, overall mortality was 8.0%(11/136) (OR 0.3 [0.2, 0.7]). After adjusting for age, only diabetes (OR 4.8 [2.0, 11.6]) and LAE+ (OR 2.4 [1.1, 5.4]) remained associated with mortality ($p<0.05$). In this outpatient cohort already referred for echocardiography, the absence of LAE+, diabetes and advanced age (≥65 years) identified a sizable subgroup, 81/240 (33% of total), with a particularly low, 1.2% (1/81) 5.5-year mortality. **Conclusions:** A quick-look sign of left atrial enlargement is associated with an increased, 23%, 5.5-year mortality and could be employed as an easily-learned POCUS exam to help stratify patient risk and refine outpatient echo referral. In particular, the lack of the LAE+ sign may be useful in decision-making when echo resources are limited or when clinical suspicion is low.

P2-33

Acute Respiratory Distress Syndrome Associated with Elevated Pulmonary Vascular Resistance

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Background: Alveolar inflammation and non-cardiogenic pulmonary edema that impairs gas exchange are the key features of Acute Respiratory Distress Syndrome (ARDS). In this disease state, the fraction of each tidal breath that participates in gas exchange is reduced, amounting to an increase in pulmonary dead space ventilation. In an effort to balance alveolar perfusion and ventilation, pulmonary arterial beds vasoconstrict to divert deoxygenated blood to healthy alveolar units, a term called hypoxic pulmonary vasoconstriction. Previous studies of ARDS have shown that an increase in pulmonary dead space ventilation is associated with higher mortality and right ventricular dysfunction (Cepkova et al., 2007; Nuckton, 2002). However, no study has characterized the relationship between pulmonary dead space, pulmonary vascular resistance (PVR), and right ventricular function throughout the clinical course of ARDS. **Methods:** This is a prospective observational case series examining the association between pulmonary dead space ventilation and PVR in critically ill patients with ARDS requiring mechanical ventilation. Subjects underwent serial non-invasive measurement of right ventricular function, pulmonary vascular hemodynamics, and pulmonary dead space ventilation fraction on days 0, 2, and 5 of enrollment. The primary predictor for this analysis was the relationship between change in pulmonary dead space and PVR, determined by unadjusted linear regression. PVR was derived via the Abbass formula using the ratio of the tricuspid regurgitation jet velocity to the right ventricular outflow track velocity time integral (Abbas, 2013). Pulmonary dead space fraction was calculated by the Enghoff modification of the Bohr equation using the partial pressure of mixed-expired and arterial CO2. **Results:** In this analysis of serial observations in our first 18 subjects, there was a significant positive correlation between pulmonary dead space fraction and PVR ($r=0.64$, $p=0.0013$). On average, PVR increased by 0.2 woods units for every 10% increase in absolute pulmonary dead space fraction (95% C.I. 0.08-0.29, $p=0.001$). **Conclusions:** ARDS is associated with increased pulmonary dead space ventilation and a moderate increase in pulmonary vascular resistance, which likely contributes to the high incidence of ARDS related right ventricular dysfunction. We speculate that this correlation is due to hypoxic pulmonary vasoconstriction and/or pulmonary vascular injury. Further research to determine the effect of ARDS on right ventricular function is warranted.

P2-34

Feasibility of Contrast Enhanced Hand Held Echocardiography in the Cardiovascular Critical Care Unit

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Background: Echocardiography is the cornerstone for cardiovascular imaging in the critical care unit. Focused cardiac ultrasound using hand-held echocardiography (HHE) devices has been shown to be an effective means for the acquisition of critical information aiding clinical decision-making. Patients within the cardiovascular intensive care unit (CVICU) are among the most technically challenging from an imaging standpoint, necessitating contrast echocardiography with left ventricular opacification (LVO). We sought to evaluate the feasibility of using hand-held echocardiography (HHE) with LVO in the CVICU. We further hypothesized that cardiology trainees would be sufficiently skilled in order to obtain diagnostic images. **Methods:** We conducted a prospective, single-center blinded, comparative study in our CVICU. Subjects undergoing a clinically indicated, standard-of-care echocardiogram (SCE), where LVO was deemed necessary, were consented for participation. Parasternal and apical images, with and without LVO, were obtained by a trainee and stored anonymously. Left ventricular wall motion was divided into 7 territories including anterior, anteroseptal, inferoseptal, inferior, inferolateral, anterolateral, and the apex. Left ventricular ejection fraction (LVEF) and left ventricular wall motion were reported by the trainee and separately by a board-certified cardiologist, both blinded to the SCE results. The non-contrast and LVO enhanced LVEF from the trainee and the cardiologist were compared using Pearson's correlation coefficient as was the LVO enhanced LVEF to the SCE LVEF. The number of territories able to be assessed was compared between the non-contrast and the LVO enhanced images. **Results:** 44 subjects were included (27% with cardiogenic shock and 16% after cardiac surgery). The most common indication for the SCE was for assessment of LVEF (48%). HHE performed very well in novice hands with good agreement between the trainees and the cardiologist ($r = 0.79$ for non-contrast images and 0.84 for LVO enhanced HHE). There was excellent correlation with SCE when LVO was added to HHE (trainee $r = 0.90$, cardiologist $r = 0.84$). More territories were able to be assessed with addition of LVO to HHE (72% improved to 91% for trainees, 72% improved to 96% for the cardiologist). **Conclusion:** Despite the technical challenges in CVICU patients, we demonstrated that LVO enhanced HHE is a feasible option for the evaluation of LVEF. We believe that this technology will enable more rapid availability of diagnostic information for these critically ill patients. Further study of LVO enhanced HHE is needed.

P2-35

Improving the Efficiency of Cardiac Ultrasound Training by Integrating Scaffolding and Deliberate Practice

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Background: As the use of focused cardiac ultrasound (FoCUS) spreads, there is a growing need for efficient, effective training in this modality across a variety of graduate and postgraduate medical education settings. **Methods:** We created a simulator-based FoCUS curriculum using the principles of instructional scaffolding and deliberate practice to help guide the novice's learning efforts and moderate the cognitive load of this complex learning task. The process of acquiring and interpreting cardiac ultrasound images was broken into discrete steps, with focused didactic information immediately followed by targeted simulator practice for each module. Practice complexity increased through successive modules, and learners ultimately applied their skills by completing unassisted simulator cases that involved basic cardiac pathology. Immediate visual and quantitative feedback was provided by the simulator during practice. This scaffolded curriculum was then compared to a previously validated, traditional didactic-before-practice curriculum in a randomized study of cardiothoracic surgery residents and cardiac nurse practitioners. Both curricula were simulator-based, entirely self-guided, and contained a similar number of practice cases. Pre- and post-training tests assessed technical skill in image acquisition using simulator scanning cases and cognitive skill in image interpretation using multiple choice questions (MCQ). **Results:** Twenty-four learners were included in this study: 11 in the traditional curriculum group and 13 in the scaffolded curriculum group. Compared to the traditional curriculum, the completion rate was significantly higher for the scaffolded curriculum (92% vs 45% of learners, $p<.00001$), and the scaffolded curriculum decreased completion time from 9.2 ± 6.5 hrs ($n=5$) to 5.4 ± 2.3 hrs ($n=12$, $p=.08$). Although the low completion rate of the traditional curriculum precluded statistical comparison of outcomes between groups, achievement of cognitive and technical skills was comparable in both curricula (Table 1). **Conclusions:** Compared to a didactic-before-practice approach, a curriculum utilizing scaffolding and deliberate practice improves learning efficiency and helps more novices achieve basic skills in FoCUS image acquisition and interpretation.

Pre- and Post-training skills outcomes. Values are mean ± SD.

	Pre-training	Post-training	P value
Traditional curriculum (n=5)			
Cognitive skill (mean % correct on MCQ)	45 ± 17	65 ± 13	.01
Technical skill (mean angle error in degrees)	31 ± 22	22 ± 20	.17
Scaffolded curriculum (n=12)			
Cognitive skill (mean % correct on MCQ)	38 ± 20	69 ± 16	.002
Technical skill (mean angle error in degrees)	46 ± 31	24 ± 14	.005

P2-36 Moderated Poster

Safety and Efficacy of Intra-myocardial Septal Radiofrequency Ablation for Hypertrophic Obstructive Cardiomyopathy

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Background: For patients with disabling symptoms due to hypertrophic obstructive cardiomyopathy (HOCM), Liwen procedure by percutaneous intra-myocardial septal radiofrequency ablation may be a less-invasive therapy option. The purpose of this study is to evaluate the safety, efficacy, and median-term outcomes of Liwen procedure. **Methods:** Fifteen consecutive patients with HOCM and drug-refractory symptoms underwent the Liwen procedure. These patients were assessed by imaging examination, electrocardiographic, and blood biochemistry test examination after a median follow-up of ≥ 6 months. **Results:** At six months follow-up, patients had significant improvements

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in peak left ventricular outflow tract (LVOT) gradients (resting gradient, from 91.53±26.82 to 12.47±6.96 mm Hg, P<0.001; stress-induced gradient, from 143.57±67.21 to 31.06±16·6 mm Hg, P<0.001), and interventricular septum (IVS) thickness (anterior IVS, from 24.64±4.64 to 14.15±2.38 mm, P<0.001; posterior IVS, from 24.13±4.78 to 13.79±2.81 mm, P<0.001). The reduction in IVS thickness and LVOT gradient was associated with improvement in New York Heart Association class (from 2.60±0.51 to 1.00±0.00, P<0.001), total exercise time (from 6.67±1.63 to 9.60±1.84 min, P<0.001), the wave amplitude of Rv5+Sv1 (from 4.62±2.11 to 3.67±1.82 mV, P=0.023) , and pro-BNP levels (from 868.34±566.93 to 233.64±217.48 pg/ml, P=0.026). No patient had bundle branch block or complete heart block. **Conclusions:** Liwen procedure is a safe and efficacious treatment of symptomatic HOCM that leads to a persistent reduction in LVOT gradients and sustained functional improvement.

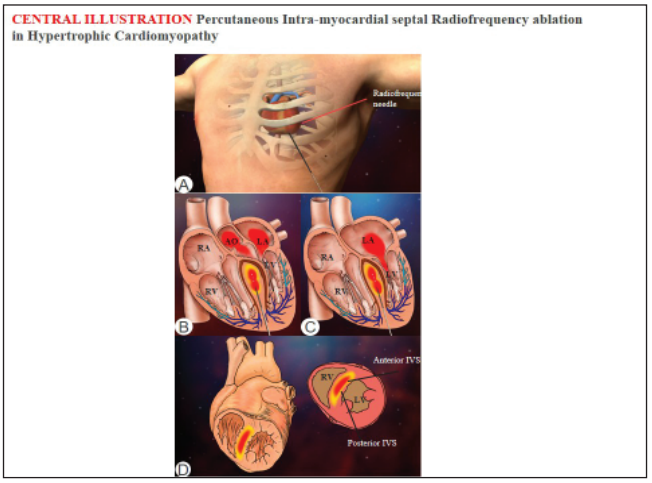
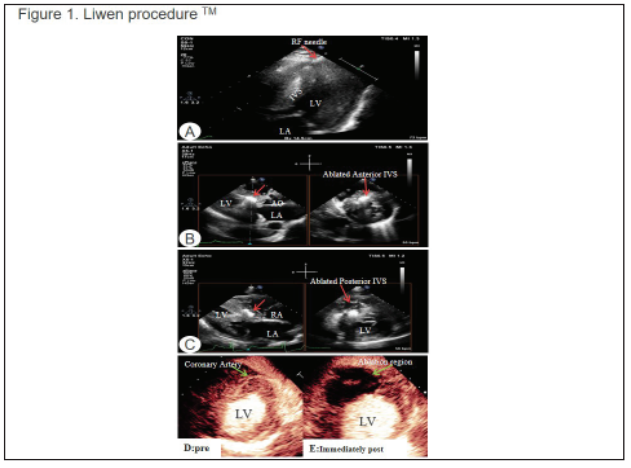
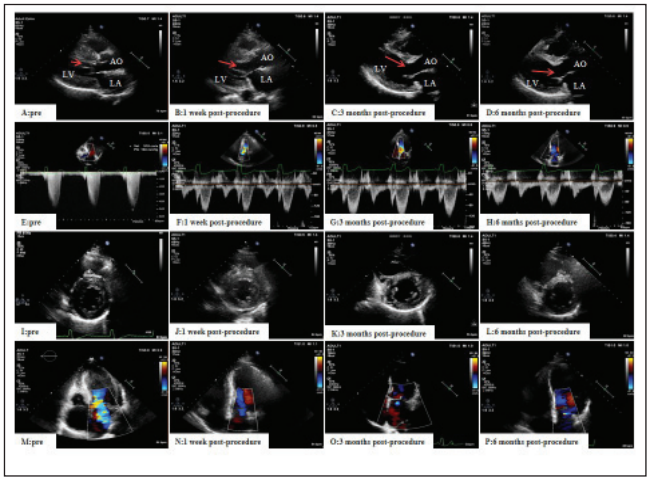


Figure 1. Liwen procedure ™





P2-37 Moderated Poster

Analysis of Aortic Stenosis using Artificial Intelligence

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Introduction: Echocardiographic (echo) evaluation of aortic stenosis (AS) requires measurements from multiple acoustic windows. Left ventricular outflow tract (LVOT) measurements are prone to error and variability, and are compounded in the aortic valve area (AVA) calculation which relies on multiplying and squaring the LVOT dimension. We evaluated whether artificial intelligence (AI) could impute the AVA from other echocardiographic data, without the need for any LVOT measurements but maintaining reproducibility. **Method:** We hypothesised that an AI model would use the phenotypic response of the heart to AS to generate a model to predict the AVA. Using data from the National Echo Database Australia (NEDA), we extracted 530,884 echocardiograms from 358,661 participants, with over 18,255,238 individual data points. Using a random 70% subset of the data we produced an AI model using multidimensional clusters, taught using the continuity equation and the known cardiac response to AS. Because of the real-world nature of the data, missing data was imputed using a multiple imputation model to build a complete data set. **Results:** Using duplicate data and withholding single parameters across the data set, the trained model imputed the missing data and showed minimal imputation error. The trained model was then tested against the remaining 30% of the data not previously seen by the AI, and again showed minimal imputation error. We then completely removed all LVOT measurements (velocity, gradient and diameter) and the AVA from the test set (n=24,748 studies), and asked the AI to predict the LVOT and AVA measurements. Severe AS was defined as AVA<1cm^2. The predicted AVA was then compared with the calculated AVA. The area under the receiver-operating characteristic curve (AUCROC) was 0.95, and area under the precision recall curve (AUCPR) was 0.73. Severe AS was present in 1834 studies (7.4%). The model performed equally well in impaired ejection fraction (EF<50%, 1391 studies, 10% with severe AS: AUCROC=0.96, AUCPR=0.78; EF<35%, 426 studies, 10% with severe AS: AUCROC=0.94, AUCPR=0.76). **Conclusion:** We have developed an AI system that completely removes the need for LVOT measurements in evaluation of AS. Our model performs equally in normal and impaired left ventricular (LV) systolic function, including severe LV dysfunction. Benefits of "smart" echo may include improved efficiency, and reduced study duration, cost and risk of sonographer injury.

P2-38

Acoustically Active Needle and Cannula for Navigation by Conventional Color Doppler Ultrasound Imaging

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Background: Fundamental limitations of B-mode ultrasound may compromise its ability to guide minimally invasive procedures. In particular, navigation of needles for percutaneous vascular entry or placement of a cannula for extracorporeal membrane oxygenation can represent a challenge. Our novel approach makes the needle or cannula tip acoustically active and, thus, identifiable by an instantaneous color marker in Doppler scans. The aim was to test acoustical navigation by color Doppler imaging in vivo. **Methods:** We installed 2-mm piezoelectric crystals at tips of a 16-gauge needle and a 5-mm in diameter cannula (Figure, A and B). Each of the crystals is driven by an external waveform generator. The vibrating crystal stimulates acoustical interactions with the transmitted ultrasound beam and generates a color Doppler marker (Figure, C and D). Tests were conducted in approximately 80-kg anesthetized closed- and open-chest adult pigs. The needle was navigated to the femoral artery. The cannula was inserted via the carotid artery and navigated to the ascending aorta. A linear array transducer was used for needle navigation and set in B-mode to 8 MHz and in color Doppler to 3.5 MHz. A phased array transducer was used for navigation of the cannula and set in B-mode to 1.7/3.4 MHz and in color Doppler to 2.0 MHz. **Results:** The needle was barely visible by B-mode imaging during insertion into the femoral artery, but its tip was clearly identified and tracked by the color Doppler marker (Figure C). The marker guided puncture of the artery. Note that blood flow patterns by color Doppler were fully preserved during acoustical navigation. The acoustic cannula tip was guided by its color Doppler marker to the ascending aorta (Figure D). In a short-axis view (Figure D, insert), the marker unambiguously localized the cannula tip within the aortic lumen. The Doppler gain was set to -20 dB in this open-chest scan. Such gain setting desirably eliminated depiction of blood flow patterns in the aorta. **Conclusion:** Our experimental tests demonstrate that color Doppler ultrasound can be used for a new purpose, ie, guidance of an interventional instrument, such as a needle or cannula. Acoustically active adaptation of their tips enabled unambiguous identification and instantaneous navigation with a conventional color Doppler echocardiography system.

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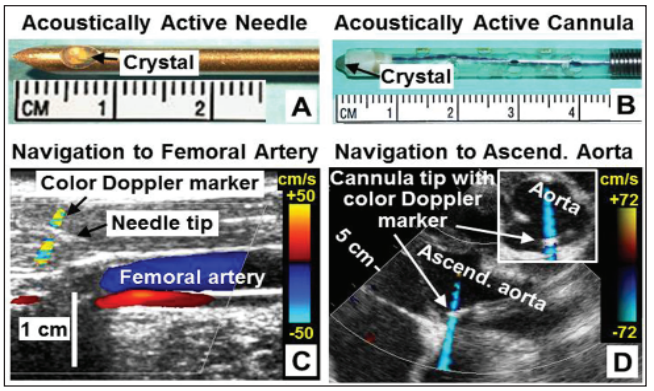

P2-39

Automated Diagnosis of Echocardiographic Views Using Deep Learning

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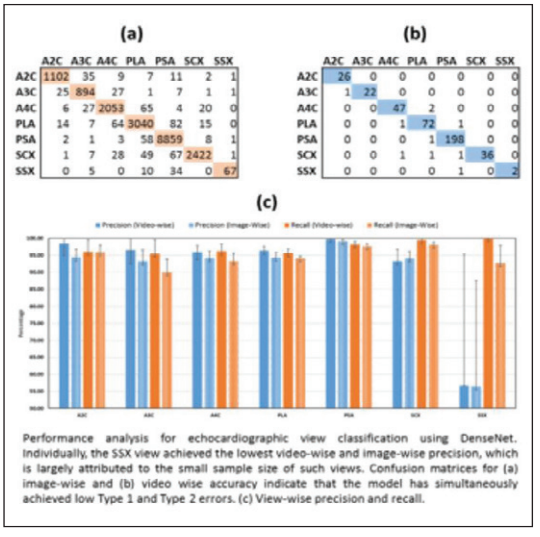
Background: Echocardiography is the cornerstone for diagnosis of cardiovascular pathology. View classification is fundamental to the interpretation of an echocardiogram. We sought to automate the image interpretation with an emphasis on the task of echocardiographic view classification. **Methods:** A densely connected convolutional network (DenseNet) model was trained on 2D echocardiographic images for all 7 standard views: parasternal long, parasternal short, apical 4, apical 2, apical 3, subcoastal, and suprasternal view. The number of echocardiographic DICOM videos and frames were of 375 and 16103, 987 and 44401, 247 and 11025, 129 and 5667, 118 and 4995, 197 and 13235, 16 and 624 respectively. The architecture used in this study alleviates the vanishing gradient problem and strengthens the feature propagation by having shorter connections between layers close to the input and output of the network. The image dataset was randomly split into training (70%), testing (20%), and validation (10%) sets, with each containing images from separate DICOM videos. The model performance was evaluated using 10-fold cross-validation. The ground truth for view classification was established by two cardiologists who were board certified in echocardiography. **Results:** The study population comprised of echocardiograms from 106 patients (mean age 58 $\pm$ 18.70 years, 51% male). The confusion matrices for both image and video-wise performance analysis on the model are shown in the figure. An average video-wise accuracy of 97.92 $\pm$ 0.55% was achieved, with precision and recall of 95.39 $\pm$ 04.50% and 97.17 $\pm$ 03.47% respectively. Automated view classification using the deep learning algorithm took approximately 0.08 seconds per image. **Conclusions:** A deep learning model was developed with an excellent diagnostic performance for automated view classification of echocardiographic images, with high accuracy, precision, and recall. Such results, when extrapolated to other aspects of echocardiographic image analysis, could reduce costs and improve workflow efficiency in healthcare burdened societies. This work lays the groundwork for the possibility of an automated echocardiogram analysis system as a first-line tool for detection and management of cardiac diseases.



Performance analysis for echocardiographic view classification using DenseNet. Individually, the SSX view achieved the lowest video-wise and image-wise precision, which is largely attributed to the small sample size of such views. Confusion matrices for (a) image-wise and (b) video wise accuracy indicate that the model has simultaneously achieved low Type 1 and Type 2 errors. (c) View-wise precision and recall.

P2-40

EQ Mutant Mice: A Novel Animal Model of LV Outflow Track Obstruction

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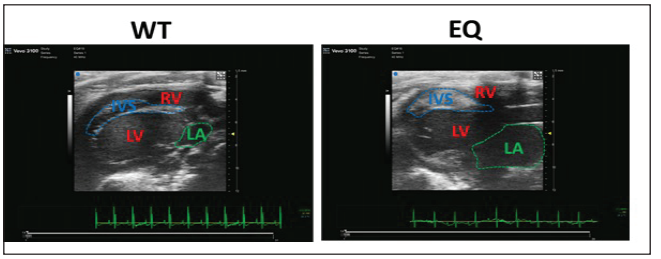
LV Outflow Track Obstruction (LVOTO) is a serious aliment which leads to dilated heart failure and death. Currently there is no other treatment except surgically removing the obstructive mass. There is an urgent need to find a cure for this debilitating disease. The advances in this field is hindered by the ack of proper experimental models for testing new therapeutic innovations. Recently we discovered that, genetically mutating the E4872Q gene which regulates ryanodine receptor 2 in cardiomyocytes in mouse (EQ mouse) led to a significantly thickening of LV IVS and created an outflow track obstruction similar to what we observed clinical cases. Echocardiographic examinations on 20 months old EQ mice (compared to wild-type siblings) showed: a significant lower HR; a significant calcification in LV endocardium and papillary muscles; a significantly increased arrhythmia; a significant enlarged IVS that obstructs LV outflow tract during early systolic phase; a significant myocardial hypertrophy; a significantly enlarged LV chamber sizes; a significant enlarged LA which indicates a presence of diastolic dysfunction; and a significant lower EF. This is the first animal model with all the hallmarks of LVOTO.



P2-41

Feasibility of Using 3D Echocardiography to Create Virtual Reality Environment

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Background: Virtual reality (VR) is a promising new technology that can aid in the visualization and understanding of complex anatomy and pathology. While most 3D reconstructions in medical imaging are viewed using 2D computer screens, VR allows true 3D visualization and interaction with datasets using specialized headsets. At present, 3D anatomic models used in VR environments are typically created from computed tomography (CT) or magnetic resonance imaging (MRI) data. The use of 3D echocardiography (3DE) to create VR environments has not been described. The aim of this study was to test the feasibility of using 3DE datasets to generate 3D models and to use them in a novel customized VR environment. **Methods:** 10 pre-selected high quality clinical 3D transesophageal echocardiograms (TEE) of various pathologies were used for the study (Table). The native 3DE DICOM data were segmented and converted into 3D surface models. Additionally, a novel prototype VR environment was created using a VR development platform (Unity Technologies). This VR environment enables the user to instantly load, view and interact with the 3D models using a commercially available VR headset (VIVE, HTC Co.) (**Figure**). Feasibility of converting a 3DE dataset into a VR compatible 3D model was tested by having two independent blinded reviewers identify the major pathology. **Results:** All of the 10 3DE datasets were successfully converted into static (single frame) and dynamic (multi-frame) VR compatible 3D models. Time required for conversion of a single static and dynamic dataset was 8±3 and 12±5 minutes, respectively. The converted datasets were characterized by both reviewers as highly realistic, and both reviewers found the ability to view from any perspective and interact with the 3D models as having a great diagnostic potential. Both reviewers correctly diagnosed the major pathology on the VR environment in the majority of cases. **Conclusions:** VR is a novel, exciting tool that allows true 3D visualization of imaging datasets in an interactive environment. This is the first study to demonstrate the feasibility of translating 3DE TEE data into 3D models that can be viewed in a VR environment. Further studies to determine the diagnostic potential role of VR in 3DE are needed.

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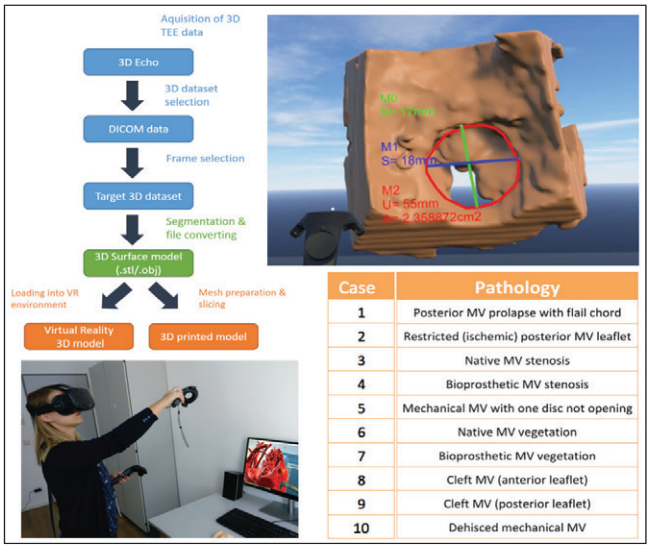

Case	Pathology
1	Posterior MV prolapse with flail chord
2	Restricted (ischemic) posterior MV leaflet
3	Native MV stenosis
4	Bioprosthetic MV stenosis
5	Mechanical MV with one disc not opening
6	Native MV vegetation
7	Bioprosthetic MV vegetation
8	Cleft MV (anterior leaflet)
9	Cleft MV (posterior leaflet)
10	Dehisced mechanical MV

P2-42

Blood Speckle Imaging: Initial Experience in Pediatric Cardiovascular Disease

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Background: Cardiac flow patterns such as vortices and helical formation represent a new challenge to interpret the dynamic interaction between blood and the contracting cardiac muscle. Conventional color Doppler technology (cD) is limited by its angle dependency (limited to radial velocities) and color aliasing. We explore the current application of blood speckle imaging (BSI) in pediatric cardiovascular disease (CVD). **Methods:** BSI is based upon the tracking of speckles created by moving blood cells, from one frame to the next using a "best match" search algorithm. It allows direct assessment of 2-dimensional blood velocity vectors without the use of contrast or mathematical assumptions used in cD. Due to the high rate of decorrelation of moving blood speckles, the acquisition frame rate must be very high. This ultrahigh framerate acquisition is obtained using a plane wave imaging technique. Studies were performed on Vivid E95 (GE Healthcare) with 6S probe. Using BSI, we prospectively assessed healthy children and a variety of CVD. The qualitative parameters evaluated were laminar atrioventricular inflow, vortex formation, helical systolic flow (HSF) and the effect of variable Nyquist limit (Nq) on flow patterns. **Results:** Overall, the vast majority of patients had laminar inflow, vortex formation, and HSF, with qualitative variability in the flow patterns in patients with CVD (Table 1 for demographic and qualitative assessment findings). Lower Nq improved vector detection, however there was an observable tendency to increase flow artifact and bleeding into tissue. The assessment of valvar disease and intracardiac shunt flow patterns were met with varying results. **Conclusion:** BSI is a novel ultrasound method to qualitatively evaluate blood flow patterns in pediatric cardiovascular disease and is an emerging area for research. Further ability to validate and quantify BSI will be important to develop clinical applicability.

	Total (n=45)	Normal (n=9)	Cardiovascular disease (n=36)
Age (years)	4.1±6.7	6.0±6.0	3.7±6.8
Weight (kg)	17.5±21	31.5±29	14.0±16.7
Body surface area (m^2)	0.6±0.5	0.9±0.6	0.5±0.4
Abnormal ventricular function	9/45 (20%)	0/9 (0%)	9/36 (25%)
Laminar inflow*	38/39 (97%)	8/8 (100%)	30/31 (97%)
Inflow vortex*	40/40 (100%)	8/8 (100%)	32/32 (100%)
Helical systolic flow*	35/38 (92%)	8/8 (67%)	27/30 (90%)
Variable Nyquist*	25/45 (56%)	6/9 (67%)	19/36 (53%)

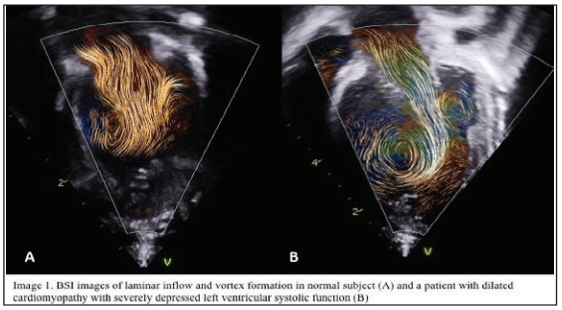

Image 1. BSI images of laminar inflow and vortex formation in normal subject (A) and a patient with dilated cardiomyopathy with severely depressed left ventricular systolic function (B)

P2-43

Does Artificial Intelligence and Deep Learning Architecture System Accurately Measure Left Ventricular Systolic Function?

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Background: Left ventricular ejection fraction (LVEF) is the most used measurement in the assessment of cardiac function. However, human error and image quality are among several factors contributing to inaccuracies of this measurement. The purpose of this study was to establish the correlation between LVEF measured by expert ultrasound cardiac sonographers and by a system based on a deep learning architecture and geometry processing algorithms. **Methods:** We developed a system based on a novel deep learning architecture and geometry processing algorithms for building a computational pipeline. Input was from a stream of cardiac ultrasound images that automatically calculated the ejection fraction of the left ventricle (LV). The system analyzes each image, identifies the viewing direction, segments the left ventricle, identifies systolic/diastolic frames and reconstructs 3D models of the LV at different times (see Figure 1). It then computes robust estimation of the ejection fraction. Echocardiographic images from of 114 patients were used. Each case contains cardiac ultrasound clips from two and four-chamber views fed to the system as a single stream with no additional data. We created the ground truth ejection fraction (EF) value for each case by taking the median of 8 estimators: 4 expert cardiologists eye-ball estimations, 3 computations using Simpson formula and 3D reconstructions based on marked LV segmentations of an expert technician, and the original medical report. **Results:** Figure 2 depicts error histograms comparing EF values and the ground-truth EF values. We compared the error histogram of our algorithm (right) and that of one of the experts (left). The mean and variance of histograms is comparable indicating our algorithm is comparable in accuracy to an expert cardiologist. **Conclusions:** An excellent correlation was found between LVEF measured by expert Ultrasound cardiac sonographer and the LVEF measured by a system based on a deep learning architecture and geometry processing algorithms.

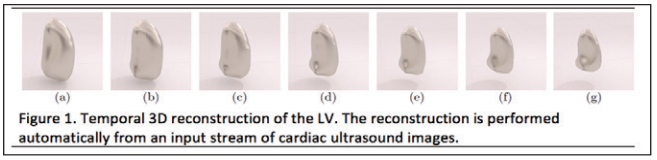

Figure 1. Temporal 3D reconstruction of the LV. The reconstruction is performed automatically from an input stream of cardiac ultrasound images.

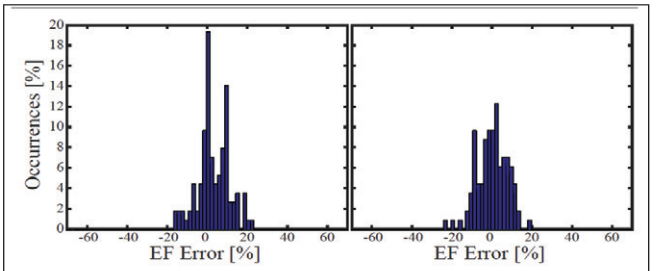

Figure 2. Comparing histograms of the errors between the estimated ejection fraction and the ground truth on 114 subjects. Left, an expert histogram; right, our algorithm errors. Note the similarity between the histograms (mean and variance).

P2-44

Reduction of *R*Rad is a Safe, Stable Positive Inotrope

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Background: Heart failure with reduced ejection fraction is progressive and irreversible; however, treatment options to improve cardiac output are limited. Rad is a protein that governs L-type calcium channel gating and reduction in Rad results in increased calcium handling. Humans with non-ischemic heart failure have reduced Rad levels. Thus, Rad reduction may represent a compensatory mechanism to normalize cardiac function. **Objective:** To test the hypothesis that cardiac specific Rad reduction increases calcium current that produces a stable increased heart rate with preserved cardiac systolic function. **Methods:** Male and female mice were used to induce knock-out cardiac-restricted Rad in adult mice. Echocardiography and isoproterenol stress echocardiography were used to evaluate in vivo heart structure and function. The echocardiography experimental design consisted of a hybrid longitudinal design and population study of gene effect. The experiment followed these mice for 15 months with echo imaging every 3 months. A cohort of mice was for heart harvest to test cell physiological mechanisms. **Results:** Echocardiography demonstrates increased cardiac function without ventricular hypertrophy or an increase in chamber dimensions. Gain-of-function was noted 7days after gene knockout induction (EF, 64±3% & 76±3%, baseline & 7d respectively, p =0.001, n=16). These positive inotropic effects persisted through 15 months. Survival was unaffected. Stress echocardiography demonstrated preserved responsiveness to

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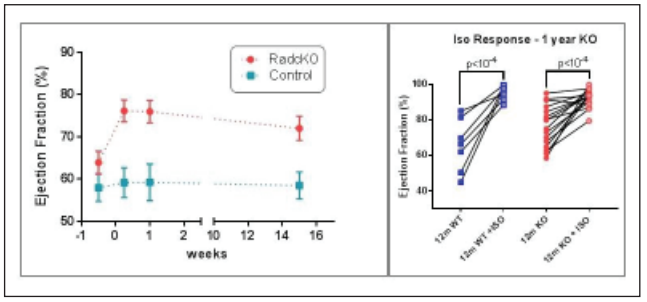
β-adrenergic stimulation into senescence in cardiac specific Rad deletion. At the cellular level Ca^{2+} homeostasis was elevated manifested through increased L-type calcium current, increased amplitude of Ca^{2+} transients and a change in sarcomere length. **Discussion:** Decreased Rad expression in native hearts may be a compensatory mechanism to preserve cardiac contractile function in the setting of cardiac stress. Reduction of RRAD in adult mice increases calcium homeostasis leading to an underlying stable positive inotropic gain of heart function. In contrast to heart failure from calcium overload, Rad-reduced myocardium retained responsiveness to β-adrenergic stimulation. **Conclusion:** We conclude that reduction of cardiac Rad represents a novel means for positive inotropic support.

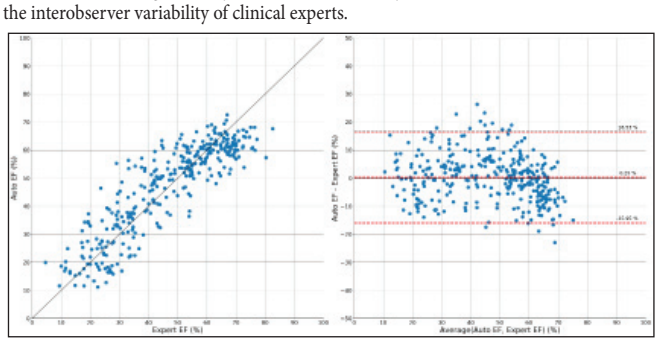


P2-45

Deep Learning Algorithm for Fully-Automated Left Ventricular Ejection Fraction Measurement

Nicolas Poilvert[1], Ha Hong[1], Nathanael Romano[1], David Adams[1], Charles Cadieu[1], Richard Y. Bae[2], Randolph P. Martin[1,3]. [1]Bay Labs, Inc., San Francisco, CA; [2]Abbott Northwestern Hospital, Minneapolis, MN; [3]Emory University Medical School, Atlanta, GA

Background: The modified Simpson's biplane method of discs is the ASE recommended two dimensional echocardiographic method used to measure Left Ventricular Ejection Fraction (EF). Automated approaches to calculate EF have the potential to reduce exam time and measurement variability. However, existing automated EF methods have limitations: they require manual selection of correct views and clips, and often produce endocardial border tracings that require manual correction. We developed and tested novel software based upon deep neural network technology, EchoMD AutoEF, that calculates EF in a fully automated manner. The goal of this study was to compare the accuracy of the fully automated EF to the standard biplane method. **Methods:** 405 digitally archived transthoracic echocardiographic studies with reported biplane EF values were included (241 male / 164 female, age 17 to 96, mean 67, median 69). A wide range of body mass index (BMI) and EF values were represented, with 33% in BMI > 30 range and 33% with EF below 35%. The software automatically searched through each entire patient study and selected optimal apical four chamber and apical two chamber clips for EF calculation. Automated EF was compared to the biplane EF and analyzed using Bland-Altman analysis and Root Mean Square Deviation (RMSD). **Results:** The echocardiographic view and image quality assessment function of the algorithm accepted 337 (83.2%) of the studies as adequate for EF calculation. The analyzed studies showed a low bias of 0.29% (-15.95%, 16.53% limits of agreement) (see figure). Ejection fraction variability of EchoMD AutoEF, measured as RMSD, was 8.29%, significantly smaller than reference inter-observer variability of 9.2% (p = 0.002). **Conclusion:** EchoMD AutoEF is an accurate and fully automated method of calculating ejection fraction from complete studies without user intervention. It also performs well on obese patients and on patients with a range of abnormal EF. It requires no manual clip selection or tracing. EchoMD AutoEF significantly reduces the variability of EF measurement compared to the interobserver variability of clinical experts.



P2-46

Reduced Mitral Valve Annular Height to Commissural Width Ratio in Young Adult Carriers of Genes for Familial Hypertrophic Cardiomyopathy

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Background: The shape of the mitral valve annulus can change with abnormalities of cardiac structure and function. The mitral valve annular height to commissural width ratio (AHCWR) may change before clinical symptoms or impaired cardiac functions occur. The aim of this study was to determine whether abnormalities in mitral valve AHCWR could be associated with the early cardiac abnormalities in young adults who were carriers for hypertrophic cardiomyopathy (HCM) gene mutations. **Methods**: The genes from 29 probands with known familial HCM and more members of a family pedigree, were sequenced by whole-exome sequencing (WES). Genotypes were identified by Sanger sequencing in young adult family members aged <30 years, and were divided into the following three mutation groups: gene (+) phenotype (+)(n = 29); gene (+) phenotype (-) (n = 27); gene (-) phenotype (-) (n = 42). Three-dimensional (3-D) echocardiographic images were obtained for the family members of all three groups. **Results:** In the three groups studied within the one family, there was no significant difference in LVEF. The interventricular septum (IVS), left ventricular posterior wall thickness (LVPWT), and Tei index of the gene (+) phenotype (+) were significantly different from the other two groups ($p<0.001$). The AHCWR of the gene (+) phenotype (-) group was significantly lower than that of gene (-) phenotype (-) group ($p<0.01$). There was no significant difference between the proband group and the other two groups. **Conclusion:** The mitral valve AHCWR was reduced in asymptomatic family members carrying HCM-associated genes. Quantitative analysis of 3Dechocardiography for measurement of mitral valve AHCWR may be used as a parameter for the early detection of cardiac dysfunction in young adults who are carriers of HCM genes.

P2-47

Myocardial Stiffness by Longitudinal Wave Propagation Using Finite Element Modeling and Clinical Data

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Background: The theory of wave propagation in elastic tubes has been recently applied to the heart and validated against the gold-standard myocardial stress-strain relationship to provide an estimate of myocardial elasticity. Herein, our aims were 1) to reproduce this wave in a simplified heart model; 2) to evaluate how wave speed varies with material properties and chamber geometry; and 3) to compare results with findings from patients with cardiac amyloidosis (CA), who are expected to have alterations in myocardial stiffness. **Methods:** Simulations were computed in ABAQUS. A simplified 3D heart wall model of a human left ventricle (LV) was modeled as a bullet-shaped geometry (Fig.A). The chamber tip was anchored with a semi-rigid coil. Gravity was considered negligible. A longitudinal wave was generated by applying a displacement boundary condition on the basal segment to simulate mitral annulus displacement during late diastole in a normal subject. The resultant wavefront of local displacements was used to measure wave speed (c_m). Measurements were repeated at various levels of diameter (D), thickness (h) and tissue Young's elastic modulus (YEM) and compared vs a reference longitudinal wave speed (infinite elastic medium, $c_L=\sqrt{YEM/\rho}$). In the clinical study, 8 patients with cardiac-biopsy proven CA and 8 normal subjects (matched for age and LV size) had noninvasive measurements of longitudinal wave speed in the LV by tissue Doppler (360-460fps, apical views). **Results:** Computer modeling showed that c_m closely correlated with the reference wave speed (Fig. B) over a wide range of elastic moduli (2 to 60kPa). By varying thickness by 33%, diameter by 30% and YEM by 100% (mild disease), c_m changed by -2.6%, 0.6% and 42%, respectively (Fig. C). In patients with CA, the wave speeds were much larger than controls (Fig.D), most likely reflecting differences in tissue properties rather than alterations in LV geometry. **Conclusion:** Longitudinal wave propagation was reproduced in a simplified ventricular model. Variations in material properties had the most influence on wave speed, while geometry played a minor role. These results build confidence in the theory that changes in wave speed in patients with cardiomyopathies reflect predominantly tissue properties that are altered by disease rather than morphologic abnormalities.

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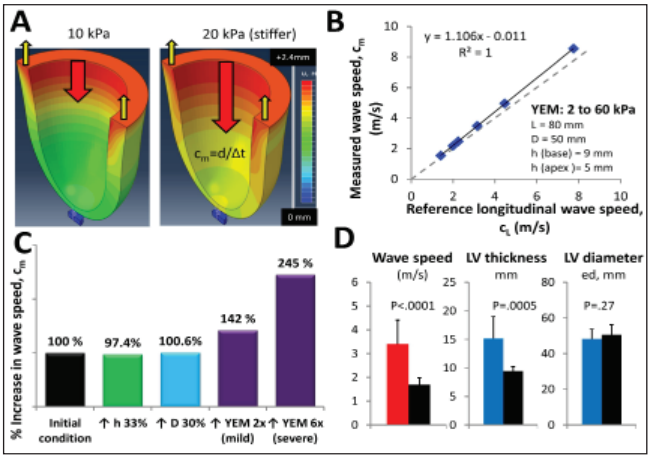
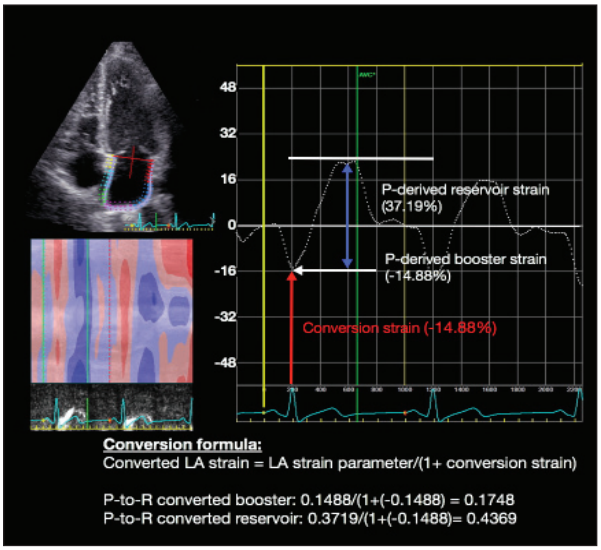


P2-48

P-to-P vs R-to-R Gating in Left Atrial Strain: Evidence That They can be Interchanged Mathematically

Menhel Kinno, Nausheen Akhter, Vera H. Rigolin, James D. Thomas. Northwestern University, Chicago, IL

Background: Left atrial (LA) strain is a novel approach for the assessment of LA function. However, there is controversy about the preferred gating method (P- vs R-wave as the reference point), as these methods result in different values. In this study we present and test a formula to convert the values of P-wave derived LA booster and reservoir strain to R-wave derived ones and vice versa. **Methods:** As shown in the figure, we hypothesized that P-derived booster and reservoir strain would be smaller in magnitude than their R-derived counterparts, but could be converted by dividing by 1+ conversion strain (the P-derived strain at the R-wave). A similar formula was used to convert LA strain from R-to-P but instead the conversion strain is at the P-wave. We studied 12 consecutive healthy volunteers who underwent comprehensive echo including speckle-tracking derived LA strain (GE Healthcare EchoPAC 202). In the apical 4-chamber view, LA strain was first measured using the P wave as the reference point (P-P) (Figure). Without changing the image frame or endocardial tracing, the gating was moved to assign the R-wave as the reference point (R-R). In the second method, the reservoir corresponds to the positive peak atrial strain and the booster as the positive strain at the onset of P-wave. Paired t-test and bivariate correlation were used for analysis. **Results:** Directly measured P-derived booster and reservoir were significantly different when compared to those directly measured by R-R method (11.9±4.2% vs 13.8±4.6%, p=0.01 and 21.9±4.1% vs 23.7±4.0%, p=0.0007, respectively). P-to-R converted booster and reservoir strain were not different to directly R-R measured ones with a correlation coefficient (R) of 0.84 (p=0.0007) and 0.91 (p<0.0001), respectively. Similarly R-to-P converted booster and reservoir were not different from the directly measured ones with R of 0.79(p=0.002) and 0.90 (p<0.0001), respectively. **Conclusion:** This conversion formula provides a quick and accurate way to interchangeably convert LA booster and reservoir strain when obtained using different gating references.



P2-49

Increased Left Ventricular Energy Loss Occurs in the Patients with Aortic Stenosis

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Objective: To analysis the left ventricular vortex parameters and blood energy loss(EL) in aortic stenosis (AS) patients using vector flow mapping(VFM). **Methods:** The study consisted of 37 patients with various degrees of AS; 16 mild to moderate ones (AS1 group) , 21 severe ones (AS2 group), and 35 age- and gender-matched normals. Using Aloka Prosound F75 color Doppler ultrasound diagnostic system to acquire standard dynamic apical long axis view color Doppler flow images during 3 completed cardiac cycles for DAS-RS1 off-line workstation. Based on time-flow curve(T-F curve)of left ventricular and the open-close of valve, the diastole period of left ventricle was divided into the isovolumic relaxation phase(P1), rapid filling phase(P2), slow filling phase(P3), atria contract period (P4), and total diastolic phase(P0). The systole period of left ventricle was divided into isovolumetric contraction phase (P5), rapid ejecting phase(P6), slow ejecting phase(P7), and total systolic phase(P8). To acquire vortex area, vortex circulation and EL of three groups in above phases. **Results:** 1.①Three peaks of EL appear in one cardiac cycle in P2, P4 and P6 respectively. Besides, the EL in total systole and diastole is equal.②Among three groups, The EL of AS1 group increased in all phases , but only in P4, P7 and P0 with significant differences (P<0.05). the EL increased in all phases of AS2 group (P<0.01). 2. ①There were both significant positive correlations between P0-EL, P8-EL and LVMI (r was 0.56, 0.59 / 0.64, 0.65 respectively,P<0.01); ②For AS group, there were positive correlation between P0-EL, P8-EL and MPG (r was 0.63, 0.52 respectively,P<0.01) . ③For control group and AS group, there were both significant positive correlations between P2-EL and E,e'(r was 0.62, 0.54 / 0.58, 0.50 respectively,P<0.01); there were both significant positive correlations between P4-EL and A(r was 0.48 / 0.56,P<0.01; there were both significant positive correlations between P0-EL, P8-EL and E/e'(P<0.01) and negative correlation between P0-EL, P8-EL and LVEF (P<0.01). ④There were positive correlation between P2-EL,P3-EL,P4-EL,P5-EL and circulation (P<0.01). **Conclusions:** Left ventricular energy lossincreased in the patients with aortic stenosis. VFM is expected to provide a sensitive indicator for early assessment the cardiac functional in AS patients.

P2-50

Lung Doppler Signals Provide a Novel Method to Monitor Filling Pressure in Congestive Heart Failure Patients

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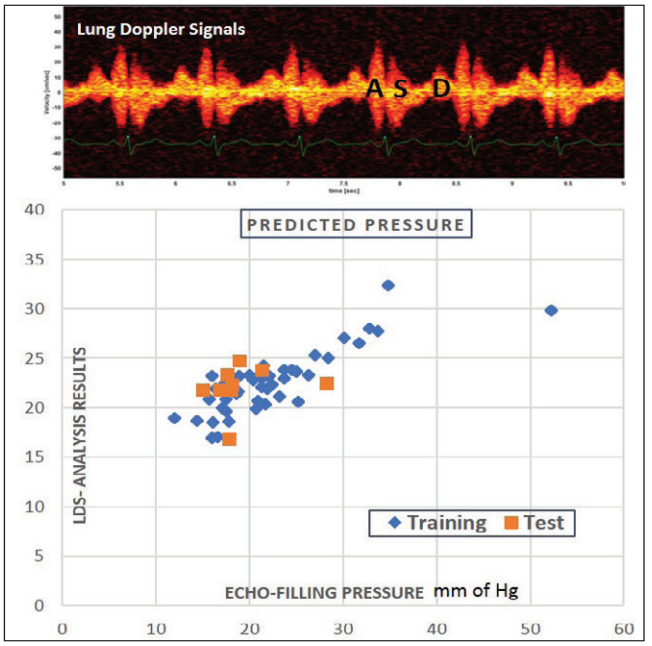
Background: Lung Doppler Signals (LDS) have been shown to detect pulsatile mechanical waves in pulmonary vessels generated by cardiac activity. We investigated the feasibility of LDS in non-invasive assessment of filling pressures in hospitalized congestive heart failure (CHF) patients. **Methods:** Total fifty-five (n=55) hospitalized CHF patients with echo derived elevated filling pressures (E/e' > 14) were investigated. LDS data was acquired within six hours of echo around admission, from over the right chest at three levels (apex, mid and base) with a non-imaging pulsed Doppler device consisting of a 2MHz single element transducer (Viasys Healthcare, Madison, WI, USA) coupled with an electrocardiogram. Both Echocardiography and LDS exams were repeated around the time of discharge. Recorded LDS were analyzed by a signal processing and algorithm package (Transthoracic parametric Doppler, TPD, Echosense Ltd, Haifa, Israel) to quantify a set of features including the Diastolic (D) signal duration, the D signal symmetry and the fall-slope of the systolic signal. **Results:** Features selection using a set of the eight significant features (p-value < 0.005) were used in a multivariable regression machine learning model (Figure B) to obtain the relation of LDS derived features and echo derived filling pressure in an exploratory cohort of 45 patients. Data from remaining 10 patients used as a validation cohort and showed similar predictable relationship. **Conclusions:** LDS derived features can be used for predicting LV filling pressure and may serve as a non-invasive tool for monitoring CHF patients.

Poster Session 2 (P2)

Monday, June 25, 2018



P2-51

Left Atrial Longitudinal Strain Differences between Diastolic Dysfunction Grades in Consecutive Patients with Severe Aortic Stenosis before Transcatheter Aortic Valve Replacement

Diego Medvedofsky[1], Tatsuya Miyoshi[1], Edward Koifman[2], Toby Rogers[2], Gai Jiaxiang[2], Itsik Ben-Dor[2], Lowell Satler[2], Rebecca Torguson[2], Ron Waksman[2], Federico M. Asch[1]. [1]MedStar Health Research Institute, Washington, DC; [2]MedStar Washington Hospital Center, Washington, DC

Background: Although the 2016 American Society of Echocardiography diastolic dysfunction (DD) guidelines have simplified the algorithm compared to the previous recommendation, the evaluation is dependent on multivariable assessment and thus remain complicated. Left atrial (LA) longitudinal strain (LS) analysis detects subtle changes in chamber function. Peak LA strain is an emerging parameter proven to correlate with diastolic function. We aimed to assess peak LA LS according to DD grades among patients with severe aortic stenosis (AS) undergoing transcatheter aortic valve replacement (TAVR). **Methods:** We analyzed consecutive patients with severe AS that underwent TAVR between 2007-2014, who had an echocardiogram in sinus rhythm pre-procedure. Patients with pacemaker were excluded. DD grading was determined according to 2016 ASE guidelines (grades I, indeterminate I-II, II and III). LA LS by speckle tracking was derived from apical 4-chamber view (TOMTEC). Pearson correlation coefficient was obtained for peak LA LS with each of the four parameters included in the guidelines: mitral wave E/A and E/e' velocity ratios, LA volume index (LAVI) and tricuspid regurgitation (TR) peak velocity. Receiver operating characteristic (ROC) and logistic regression univariate analyses were performed to predict normal LA pressure (LAP) defined as grade I DD by the guidelines. **Results:** 250 patients were included for this analysis (82±9 years old, 41% male, LV ejection fraction 60±10%). Mean peak LA LS for grades I, indeterminate, II and III were respectively: 21.8±5.3% (N=53), 22.4±5.3% (N=44), 19.2±4.9% (N=130) and 16.6±4.0% (N=44), p<0.01. The correlation for peak LA strain and each of E/A, E/e', LAVI and TR peak velocity was poor: E/A ratio had the highest correlation (0.31). The peak LA LS ROC to predict normal LAP (grade I DD) was 0.73 with an Odds Ratio = 1.18, 95% CI 1.08-1.29, (p<0.01). **Conclusions:** In patients with severe AS undergoing TAVR, baseline peak LA LS, a single non-invasive echocardiographic parameter, worsened parallel to multiparametric DD grading. Peak LA LS should be considered as part of the DD guidelines algorithm to predict normal LAP as a single parameter.

P2-52

The Association of Left Ventricular Relative Pressure Gradient by Vector Flow Mapping with Global Longitudinal Strain Rate

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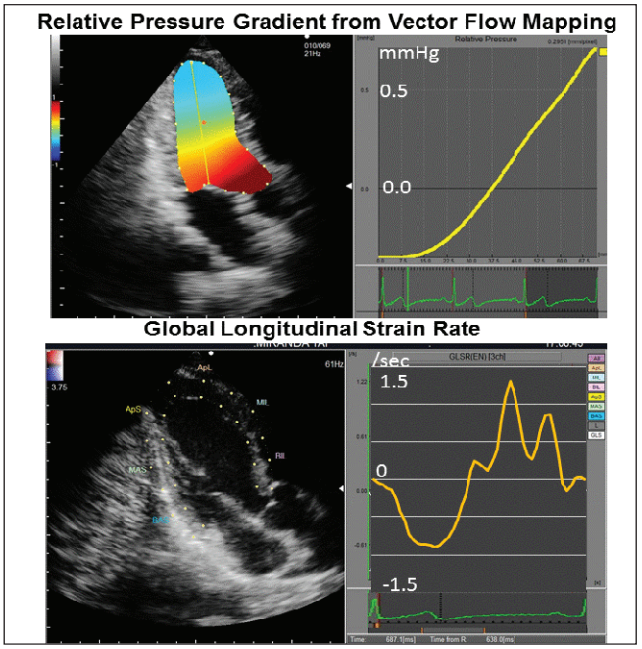
Background: The pressure difference inside the left ventricle (LV) is an indicator of cardiac performance. Vector flow mapping (VFM) is a novel technique to evaluate flow dynamics and enables estimation of relative pressure gradient (RPG) non-invasively. Our objective was to test the hypothesis that RPG relates to myocardial wall mechanics assessed by global longitudinal strain rate. **Methods:** We studied 39 healthy normal controls and 12 patients with heart failure and reduced ejection fraction (HFrEF) (LVEF<35%) by VFM and speckle tracking strain echocardiography. (PROSOUND F75 Premier CV, Hitachi Corp.). RPG was calculated using an internal LV reference from the velocity distribution of transformed Navier-Stokes equations using divergence operations. RPG was evaluated in 3 sequential cardiac cycles; in mid-systole (MS), isovolumetric relaxation time (IRT) and isovolumetric contraction time (ICT). Also, we evaluated global longitudinal strain (GLS) and global longitudinal strain rate by the speckle-tracking method. **Results:** VFM analysis were available in all 51 subjects. RPG was significantly lower in HFrEF patients than normal controls: (0.29±0.07, 079±0.08, vs 1.04±0.25, 0.17±0.31, 0.32±0.16, p=0.01, <0.01, 0.01, respectively). As expected, GLS was significantly lower in HFrEF patients than normal controls (-5.29±1.72 vs -18.53±1.36, p<0.01). We assessed wall mechanics using systolic global longitudinal strain rate, early diastolic strain rate and late diastolic strain rate comparing HFrEF patients to normal controls as follows: (-0.34±0.27, 0.79±0.31, 0.69±0.13 vs -0.91±0.11, 1.14±0.27, 0.55±0.17, p<0.01, <0.01 and 0.03, respectively). RPG during IRT was significant correlated with early global strain rate (p=0.02) and RPG during ICT was significantly correlated with systolic global strain rate (p<0.01). **Conclusions:** RPG is a novel means to assess internal LV pressure gradient in HFrEF patients and normal controls. RPG had significant associations with global longitudinal strain rate during specific times of the cardiac cycle, with differences in HFrEF patients from normal controls. RPG has promise as a new method to assess the interaction of LV wall mechanics and internal flow dynamics, which can be additive to assess cardiac performance.



P2-53

Development of Echocardiography Image Recognition Deep Learning Neural Network Algorithm to Facilitate Structured Echocardiography Reporting

Ralph Matar[1], Alexander LeClair[2], Amna Zafar[3], Jeffrey Soble[3], James Wolfer[4], Rami Doukky[1]. [1]Cook County Health and Hospital System, Chicago, IL; [2]Ascend Health Information Technology, Lisle, IL; [3]Rush University Medical Center, Chicago, IL; [4]Indiana University South Bend, South Bend, IN

Background: Transthoracic Echocardiography (TTE) digital images have been traditionally displayed according to the standardized acquisition sequence. Adaptive smart display of relevant images of interest to match structures being interrogated can facilitate structured TTE reporting. We sought to train and validate a Deep Learning Neural Network (DLNN) to identify standard TTE views. **Methods:** We randomly selected 2021 complete TTE studies from one institution. Studies were acquired by 7 different registered sonographers utilizing 5 echo machines (GE vivid 9 and E95). Discrete DICOM cine and still frame images were extracted to generate 105,048 unique image files of conventional echo imaging modalities: 2D, M-Mode, flow Doppler, tissue Doppler, color Doppler, etc. All patient and image identifiers were electronically redacted. Experienced echocardiography technologists tagged each image according to a menu of standard view nomenclature. Of the resulting images, 84,093 were used to train a DLNN to recognize 61 distinct standard views plus a single class representing all other views. The remaining 20,955 images were used to validate and optimize DLNN

image recognition. Agreement between DLNN and sonographers as gold standard was measured. Agreement among sonographers was measured as a reference. **Results:** After training the DLNN on the training image set, we validated the algorithm on the validation image set. Average agreement between the DLNN and reference sonographers was 86% for all views (P < 0.001). Agreement among sonographers was 82% (P < 0.001). The likelihood for chance agreement between DLNN and sonographers or among sonographers is 1.6%. Standard views identified using DLNN algorithm were successfully mapped to corresponding structured reporting elements. **Conclusions:** We developed and validated a DLNN capable of identifying standard TTE views with a high degree of accuracy. Image identification using DLNN can be used to facilitate structured reporting and side-by-side image comparison between concordant views derived from serial TTE studies. The developed DLNN algorithm needs to be externally validated against different set of sonographers and ultrasound machines.

P2-54

Efficacy of Shock Wave Therapy for Improving Myocardial Blood Flow Reserve in Patients with Refractory Angina: Evaluation by Real-Time Myocardial Perfusion Echocardiography

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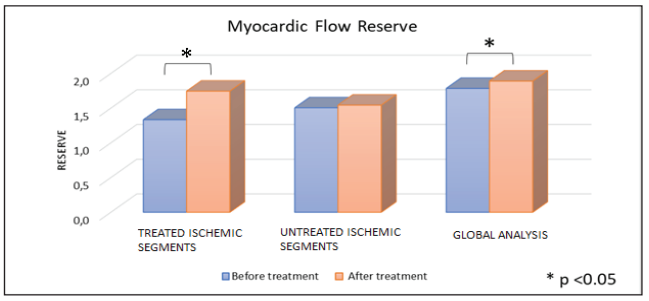
Background: Despite all the therapeutic arsenal in the treatment of coronary artery disease, the prevalence of refractory angina increases in the population. Cardiac shock wave therapy (CSWT) was proposed as an option for the treatment of refractory angina, promoting immediate vasodilatory effects and, in long term, neoangiogenic effects that would be responsible for reducing the ischemic load. The objective of this study was to evaluate the effects of CSWT on myocardial perfusion using the Real-time Myocardial Perfusion Echocardiography (RTMPE). **Methods:** We prospectively studied 15 patients with refractory angina who underwent CSWT during 9 sessions of treatment of their ischemic zone, over a period of 3 months (3 sessions per week, with a minimum interval of 48 h between sessions). A total of 32 left ventricular myocardial segments with ischemia by SPECT were treated with CSWT while other 31 ischemic segments did not receive therapy by technical limitations. The myocardial perfusion was evaluated at rest and after stress protocol with dipyridamole (0.84 mg/kg) before and 6 months after the application of CSWT, with quantitative analysis of myocardial flow reserve (MFR) by RTMPE. Clinical effects of CSWT were evaluated through the Canadian Cardiovascular Society (CCS) grading of angina pectoris and the Seattle Angina Questionnaire (SAQ). **Results:** The ischemic segments treated with CSWT presented a significant increase in MFR (from 1.33±0.22 to 1.74±0.29;p<0.001), a benefit that was not observed in non-treated ischemic segments (from 1.51±0.29 to 1.54±0.28;p=0.47). Patients demonstrated improvement in the global MFR (from 1.78±0.54 to 1.89±0.49; p=0.017). There was improvement of CCS (from 3.2± 0.56 to 1.93± 0.70;p<0.05) and in the SAQ score (from 42.3±12.99 to 71.2±14.29;p<0.05). No major cardiovascular events were recorded during the follow-up period. **Conclusions:** RTMPE was able to identify an increase in the MFR in ischemic segments, treated with CSWT. The results suggest that CSWT in patients with refractory angina is safe and has the potential to improve myocardial ischemia in the treated ischemic segments with impact on symptoms and quality of life.

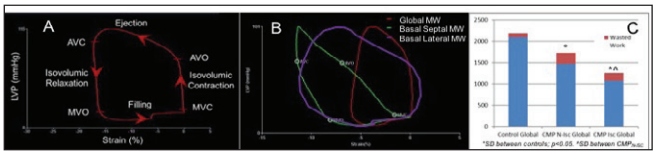


P2-55

Global Wasted Work is Elevated in Dilated Cardiomyopathy with Greater Regional Differences in Non-Ischemic Cardiomyopathy: A Study Utilizing a New and Novel Non-Invasive Left Ventricular-Pressure Strain Loop Software

Natalie FA Edwards[1], Jonathan Chan[1,2], Surendran Sabapathy[2], Bonita A. Anderson[1], Robert Chamberlain[1], Gregory M. Scalia[1]. [1]The Prince Charles Hospital, Brisbane, Australia; [2]School of Medicine and Menzies Health Institute Queensland, Griffith University, Gold Coast, Australia

Background: Left ventricular (LV) pressure-strain loop is a novel, non-invasive quantification of myocardial work (MW). Area within the LV pressure-strain loop represents global MW (GWI) (figure1A). Constructive work (CW) is calculated from myocardial shortening during systole, incorporating lengthening during isovolumic relaxation. Wasted work (WW) is calculated from myocardial lengthening during systole, incorporating shortening during isovolumic relaxation. Non-ischemic (CMP_{N-ISC}) and ischemic cardiomyopathy (CMP_{ISC}) heart disease etiology influences management, prognosis as well as electromechanical correlates in heart failure. Differences in GWI and regional MW in patients with CMP_{N-ISC} and CMP_{ISC} were assessed. **Methods:** Strain analysis was performed immediately prior to coronary angiography. 34 patients met the study criteria divided into: 1) Controls (n=10); 2) CMP_{N-ISC} (n=10) (EF<40%; no evidence of significant coronary artery disease); 3) CMP_{ISC} (n=14) (EF<40%; coronary artery stenosis). The software normalized a standard LV pressure curve to brachial systolic cuff pressure to isovolumic and ejection duration. MW efficiency (GWE) was derived from the percentage ratio of: CW/(CW=WW). Segmental wasted work between septal and lateral segments were compared between CMP_{N-ISC} and CMP_{ISC}. **Results:** GWI and GWE were significantly impaired (p<0.05) in both CMP groups. Although not significant, GWI was lower in the CMP_{ISC} (780mmHg%) vs CMP_{N-ISC} (1054mmHg%). WW was significantly higher (p<0.05) in non-ischemic vs CMP_{ISC} (259 vs 185 mmHg%). Septal WW was significantly higher (p<0.05) in CMP_{N-ISC} (459mmHg%) vs lateral WW (174mmHg%) (Figure1C). There was no significant difference between septal (198mmHg%) and lateral (161mmHg%) WW in CMP_{ISC}. **Conclusion:** Significant deterioration of GWI and GWE in both CMP groups demonstrates impaired contractility of cardiomyocytes. Prognostic significance, particularly in CMP_{ISC}, remains to be determined. Significantly higher septal WW in CMP_{N-ISC} demonstrates a higher systolic LV lengthening with segmental shortening during isovolumic relaxation (figure1B). This group of patients may likely respond to resynchronization therapy. Global and regional MW constitutes a more complete assessment of myocardial function beyond ejection fraction.

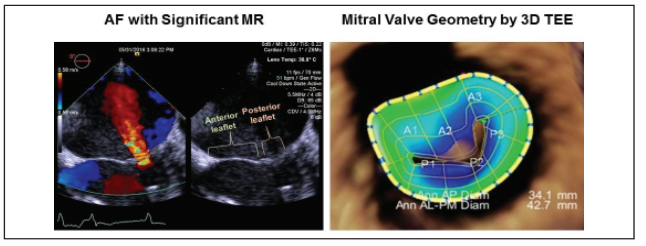


P2-56

Shortened Posterior Mitral Leaflet in Patients with Atrial Fibrillation and Significant Mitral Regurgitation

Hiroki Takada, Hidekazu Tanaka, Shun Yokota, Nao Shibata, Jun Mukai, Makiko Suto, Fumitaka Soga, Kumiko Dokuni, Yutaka Hatani, Hiroki Matsuzoe, Keiko Hatazawa, Eriko Hisamatsu, Kensuke Matsumoto, Ken-ichi Hirata. Division of Cardiovascular Medicine, Department of Internal Medicine, Kobe, Japan

Background: The underlying mechanism of mitral regurgitation (MR) in atrial fibrillation (AF) is considered as isolated annulus dilation by left atrial (LA) remodeling, known as Carpentier's functional classification Type I. However, the association of mitral valve geometry with MR in AF patients remains unclear. **Methods:** We studied 96 AF patients with preserved left ventricular ejection fraction (LVEF) who underwent transthoracic and transesophageal echocardiography. Their mean age was 66±10 years, 35% were female, and LVEF was 63±6% (all≥50%). Patients who a major cause of MR was Carpentier's functional classification Type II, IIIa and IIIb were excluded. Mitral valve geometry was evaluated with three-dimensional transesophageal echocardiography (3D-TEE) (ACUSON SC2000, Siemens). **Results:** Eleven patients were classified as MR group (≥moderate), and remaining 85 were classified as non-MR group (<moderate). In three-dimensional mitral valve geometric analysis, mitral annulus area in MR group was significantly larger (11.2±1.7cm^2 vs. 9.1±1.7cm^2, p<0.001), and relative posterior mitral leaflet (PML) area (posterior mitral leaflet area / mitral annulus area) was significantly smaller (0.51±0.06 vs. 0.58±0.09, p<0.001) compared to non-MR group. Multivariate logistic regression analysis showed that relative PML area was independently associated with MR as well as LA volume index and mitral annulus area. For sequential logistic regression models for the association of MR, a model based on clinical variables including age, gender, and LVEF (χ^2=4.5) was improved by addition of mitral annulus area (χ^2=31.8; p<0.001), and further improved by addition of relative PML area (χ^2=37.7; p<0.001). **Conclusions:** Our findings suggested that shortened posterior mitral leaflet plays an important role for the development of MR in AF patients. Therefore, the assessment of mitral valve geometry by 3D-TEE may well have clinical implications for better surgical management of AF patients with significant MR.



Poster Session 2 (P2)

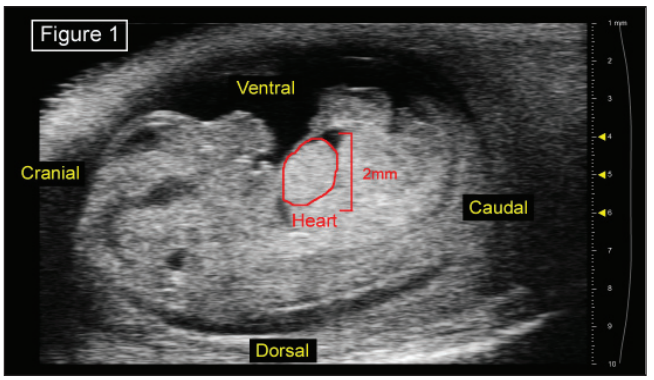
Monday, June 25, 2018

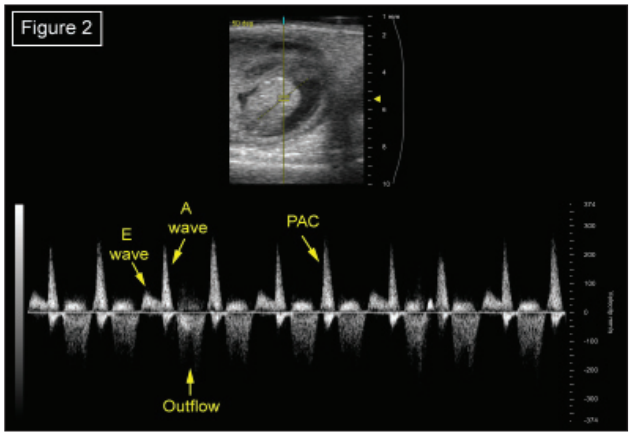
P2-57

Mutant Mouse Embryo Phenotyping using Visualsonics Vevo 2100 Ultra-High Frequency Echocardiography

Deepa Mokshagundam[1], Iris Pak[2], Danielle Donahue[3], Brenda Klaunberg[3], Yohsuke Mukoyama[2], Linda Leatherbury[1]. [1]Children's National Medical Center, Washington, DC; [2]Laboratory of Stem Cell and Neuro-Vascular Biology, Genetics and Developmental Biology Center, NHLBI, Bethesda, MD; [3]Mouse Imaging Facility, NIH, Bethesda, MD

Background: *In vivo* microimaging of mice has demonstrated the usefulness of this technique in studying the genetic basis of cardiac development in mutant mouse embryos. However, certain mutations can confer a lethal phenotype for the embryo. Newer generations of linear array animal ultrasound machines offer enhanced 2D and doppler resolution allowing for in utero study prior to expiration of the embryo. **Methods:** We examined Phox2b mice whose mutant embryos lack sympathetic innervation to the heart from E10.5 to E14.5 (1/2 to 2/3 gestation). Mouse anesthesia was provided using 1%-3% isoflurane delivered via nose cone and titrated to maintain respiratory and heart rate within specified parameters. A Visualsonics Vevo 2100 ultra high-frequency linear array ultrasound with 30mHz and 40mHz probes was used for image acquisition. Images were acquired both free-hand and using a fixed arm. **Results:** Using two-dimensional B-mode (Figure 1) and M-mode ultrasound, we were able to measure embryo size, heart size, anatomic defects, function, ventricular rate, ventricular rhythm, and ventricular contractility. Using pulse-wave doppler, we were able to acquire inflow and outflow doppler to assess for arrhythmias, AV synchrony, ectopy, and myocardial performance index. On 2D cine imaging we have seen echo bright areas of the myocardium. Using our protocol, we have seen abnormal embryo size, premature atrial contraction (Figure 2), atrial bigeminy, supraventricular tachycardia, ventricular tachycardia and abnormal ventricular contractility in these mutant mouse embryos. **Conclusion:** Newer generation of linear array animal ultrasound allows for the study of *in vivo* cardiac development and the characterization of multiple parameters of embryonic cardiac function, anatomy, and conduction. Our technique has shown promise in studying the cardiac phenotypes at sequential stages of mouse development with high-resolution.





P2-58

External Validation of a Deep Learning Neural Network Algorithm for Artificial Intelligence Recognition of Echocardiographic Images

Amna Zafar[1], Alexander LeClair[2], Ralph Matar[3], Jeffrey Soble[1], James Wolfer[4], Rami Doukky[3]. [1]Rush University Medical Center, Chicago, IL; [2]Ascend Health Information Technology, Lisle, IL; [3]Cook County Health and Hospitals System, Chicago, IL; [4]Indiana University South Bend, South Bend, IN

Background: Transthoracic Echocardiography (TTE) digital images have been traditionally displayed according to a standard acquisition sequence. Adaptive smart display of relevant images of interest to match structures being interrogated can facilitate structured TTE reporting and side-by-side comparison of serial studies. We previously trained and validated, in a single institution, a deep learning neural network (DLNN) algorithm to recognize standard TTE views, achieving 86% agreement with experienced technologists. In the present study, we sought to externally validate the DLNN algorithm in a TTE image set from a different institution, acquired by a different team of sonographers using a fleet of ultrasound machines from another manufacturer. **Methods:** We randomly selected 166 complete TTE studies from a different institution to serve as an external validation set. Studies were acquired by 9 sonographers using Phillips EPIQ7 machines, whereas DLNN algorithm was initially trained using images acquired by different sonographers using GE vivid 9 and E95 equipment. Discrete DICOM cine and still frame images were extracted from the study to generate 17,688 unique image files of conventional echo imaging modalities: 2D, M-Mode, flow Doppler, tissue Doppler, color Doppler, etc. Two senior cardiology fellows tagged each image according to a menu of standard views. The developed DLNN algorithm, trained on 61 standard views plus a single class representing all other tags, was applied to identify image views in the validation image set. Agreement between DLNN and cardiology fellows, as a gold standard, was measured. Agreement among cardiology fellows was measured as a reference. **Results:** The aggregate agreement between the DLNN and reference cardiology fellows was 43% for all views ($P < 0.001$). Agreement among fellows was 84% ($P < 0.001$). The likelihood for chance agreement between DLNN and fellows or among fellows is 1.6%. **Conclusions:** We externally validated a DLNN capable of identifying standard TTE views with a modest degree of accuracy. The study highlights the difficulties posed by applying DLNN algorithm to identify echo views acquired by different sonographers, using different equipment. Logos and image patterns generated by different manufacturers or institutions may "confuse" DLNN. The study stresses the necessity for training and validating multi-center images produced by machines from different manufacturers. Further intra-institutional optimization of DLNN algorithm may be necessary.

P2-59

Different Mechanisms of Exercise-Induced Mitral Regurgitation Between Degenerative and Functional Mitral Regurgitation: Three-Dimensional Transesophageal Echocardiography Study

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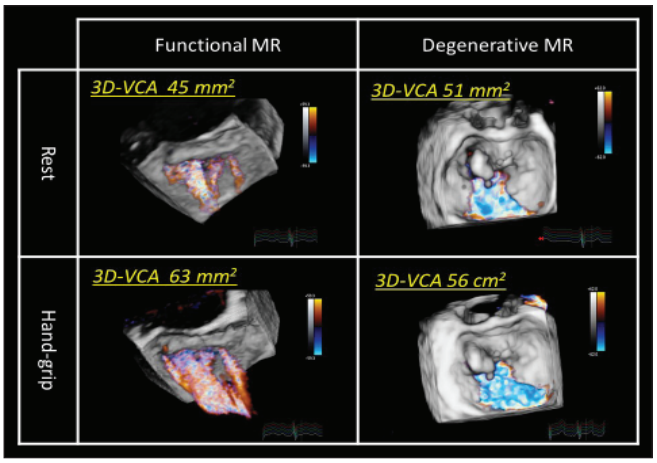
Background: Exercise-induced mitral regurgitation (MR) is an important prognosticator regardless of MR etiology. However, different mechanisms of exercise-induced MR according to MR subtypes remain unknown. The three-dimensional (3D) vena contracta area (VCA) can be measured using color 3D transesophageal echocardiography (TEE) and has shown to be an accurate parameter to quantify MR, which is validated in both circular and elliptical shape of the regurgitant orifice. The aims of this study were (1) to investigate the increase in 3D VCA (Δ3D VCA) by using hand-grip exercise 3D TEE, (2) to compare the Δ3D VCA between degenerative and functional MR, and (3) to evaluate the mitral valve (MV) geometrical effects of hand-grip exercise and its association with Δ3D VCA. **Methods:** Forty symptomatic patients with moderate to severe MR (degenerative, n=24; functional, n=16) were prospectively enrolled between May 2017 and February 2018. Using 3D TEE, anterior-posterior and anterolateral-posteromedial MV annular diameters, annular height, averaged tenting height, 3D VCA, and hemodynamic status were measured immediately before and after 5-minute hand-grip exercise. The averaged tenting height was determined in 3 anterior-posterior planes in the mid-systolic frame. **Results:** There was no significant difference in 3D VCA at rest (41±18 mm^2 in degenerative vs. 37±14 mm^2 in functional, P=0.41). During hand-grip exercise, the 3D VCA increased significantly in both MR subgroups, but a larger Δ3D VCA was observed in patients with functional MR (17±11 mm^2 vs. 6±5 mm^2, P<0.001; Figure). In functional MR, a significant augmentation in averaged tenting height was observed during hand-grip exercise (P<0.001). Meanwhile, in degenerative MR, MV annular height decreased significantly during hand-grip exercise in correlation with systemic blood pressure elevation. Univariable linear regression analysis revealed the association of Δ3D VCA with averaged tenting height in functional MR and with peak systolic blood pressure in degenerative MR (both P<0.03). **Conclusions:** Hand-grip exercise alters MV geometry and causes an exacerbation of MR. MV geometrical effects and their association with increased MR severity differ between degenerative and functional MR. Our results may impact the strategy for percutaneous treatment for MR.

Poster Session 2 (P2)

Monday, June 25, 2018



P2-60

Right Ventricular Three-Dimensional Speckle-Tracking Strain Predicts Outcome in Patients with Left Heart Failure

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Background: Right ventricular (RV) dysfunction is increasingly recognized in patients with left heart failure and is reported to be associated with poor prognosis. The aim of this study was to investigate the changes of RV function in left heart failure by three-dimensional speckle tracking echocardiography(3D-STE) and investigate the prognostic value of RV 3D-STE-derived strain. **Methods:** 155 patients with left heart failure and 32 healthy subjects were included in this study. 155 patients included 44 heart failure patients with preserved ejection fraction(HFpEF, LVEF ≥50%), 38 heart failure patients with mid-range ejection fraction(HFmrEF, LVEF 40-49%) and 73 heart failure patients with reduced ejection fraction(HFrEF, LVEF <40%). RV end diastolic volume index, end systolic volume index, ejection fraction (EF) and RV longitudinal strain of free wall were determined by 3D-STE. **Results:** RV end diastolic volume index and end systolic volume index were increased, whereas RV longitudinal strain of free wall and RVEFwerereduced in patients with heart failure.Furthermore, patients with HFpEF, HFmrEFand HFrEFyielded a gradual decrease in RVEF and RV longitudinal strain,and a gradual increasein RV volume with worsening LVEF.During theconventional two-dimensional and 3D-STEparameters,only RVlongitudinal strain differentiate patientswith HFpEF fromnormal controls (p<0.05). RV longitudinal strain (hazard ratio: 3.385; p=0.011) was independent predictors of unfavorable clinical outcomes. **Conclusion:** 3D-STE-derived RV longitudinal strain may be a sensitive parameter for RV function assessment in patients with heart failure and is associated with clinical outcomes.

P2-61

Impaired Right Ventricular Systolic Deformation in Pulmonary Hypertension Associated with Outcomes: A Three-Dimensional Speckle Tracking Echocardiography Study

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Background: Right ventricular (RV) dysfunction is a strong predictor of adverse clinical outcomes in patients with pulmonary hypertension (PH).The value ofthree-dimensional speckle tracking echocardioraphy (3D-STE) for RV function assessment has not been well established. The purposes of our study were to comprehensively assess RV function in patients with PH using 3D-STE and investigate whether 3D-STE parameters was associated with clinical outcomes. **Methods:** 60 patients with PH and 25 normal controls were studied by both two-dimensional echocardiography and 3D-STE.RV regional and global longitudinal strain (LS), circumferential strain (CS), radial strain (RS)were calculated by 3D-STE.RV end diastolic volume, end systolic volume and ejection fraction were obtained from cardiac magnetic resonance (CMR) imaging. Exercise capacity was evaluated by 6-minutes walking test. **Results:** Patients withmoderate and severe PH had increased RV end-diastolic volume and end-systolic volume, and decreased ejection fraction using CMR imaging compared with controls; our findings revealed that LS showed significant reduction in mild PH patients; in contrast, CS and RSwere decreased in moderate and severe PH patients. Patients with severe PH exhibited reduced RV global LS, RS and CS compared with patients with mild PH. RV global LS,CS and RS were significantly correlated with CMR-derived RVejection fraction(r=0.770; r=0.612; r=0.566, respectively), and 6-min walking distance (r=0.673; r=0.438; r=0.465, respectively).RV global LS and CS were negatively related to pulmonary vascular resistance(r=-0.678; r=-0.601, respectively) and pulmonary artery systolic pressure (r=-0.544; r=-0.408, respectively). Only LS improved 6 months after medical treatment. RV global LS(hazard ratio [HR]: 1.385; 95% confidence interval [CI]: 0.896 to 2.140; p=0.013), age(HR: 1.148; 95% CI: 0.962 to 1.368; p=0.015), and RVejection fraction (HR: 0.629; 95% CI: 0.425 to 0.932; p=0.021)were independent predictors of unfavorable clinical outcomes. **Conclusion:** Patients with PH show decreased 3D-STEparameters that have better correlations with CMR-derived RV ejection fraction, hemodynamic parameters and exercise capacity than conventional echocardiographic indices, and provide prognostic information.

P2-62

Semi-Automated Speckle-Tracking for Quantitative Right Ventricular Assessment in Children and Adolescents with Tetralogy of Fallot

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Background: Tetralogy of Fallot (TOF) is a congenital heart defect where assessment of the right ventricle (RV) is crucial. The anterior location of the RV and the tripartite anatomy make quantitative assessment difficult. The American Society of Echocardiography encourages quantitative assessment of the RV, which includes linear measurements, end diastolic area (EDA), end systolic area (ESA), fractional area change (FAC), tricuspid valve annular peak systolic velocity (S'), and tricuspid annular plane systolic excursion (TAPSE). Epsilon EchoInsight® utilizes speckle-tracking to perform quantitative measurements. This study aimed to evaluate Epsilon EchoInsight® by comparing semi-automated and manual measurements. **Methods:** Pediatric patients with TOF were identified. Transthoracic 4 chamber echocardiogram images were analyzed. RV measurements were obtained using manual and Epsilon EchoInsight® methods. The cohort consisted of 4 age groups. Intra and inter-rater reliability were assessed. Bias and relative difference were used as parameters of assessing measurement agreement. **Results:** Forty-six patients with TOF were included. Semi-automated measurements showed no significant difference from traditional manual measurements for the youngest and oldest groups with regards to RV basal diameter, RV longitudinal dimension, and TAPSE. The largest difference between manual and semi-automated measurements was seen in RV ESA and FAC across all age groups with semi-automated measurements reading larger for ESA and smaller for FAC. Intra and inter-rater reliabilities were acceptable. There was higher inter-rater reliability for the semi-automated method. **Conclusion:** Epsilon EchoInsight® can generate RV measurements with better inter-rater reliability compared to manual methods. The rapid semi-automated multiple RV function measurements obtained in a single heart beat by Epsilon EchoInsight® should allow for more routine quantitative assessment of RV function.

Table 1 Manual and Semi-Automated Measurements Agreement

	Overall		**>12-<18 yrs**		**>1-12 yrs**		**>4-12 mo**		**0-4 mo**	
	N=46		**N=10**		**N=16**		**N=10**		**N=10**	
	Bias	Mean relative diff (%)	Bias	Mean relative diff (%)	Bias	Mean relative diff (%)	Bias	Mean relative diff (%)	Bias	Mean relative diff (%)
RV basal diameter	-0.22	11.35	-0.18	7.71	-0.33	13.26	-0.21	12.70	-0.08	10.59
RV midcavitary diameter	0.49	19.87	0.73	18.37	0.55	21.64	0.37	20.23	0.29	18.19
RV longitudinal dimension	-0.06	6.39	-0.05	5.30	0.08	5.07	-0.15	8.65	-0.20	7.31
RV EDA	2.75	21.78	4.54	16.55	3.53	27.18	1.29	16.57	1.17	23.58
RV ESA	4.23	46.82	8.29	44.70	4.42	45.78	2.32	47.21	1.79	50.24
RV FAC	-17.48	51.71	-18.77	51.98	-14.10	41.37	-20.43	62.58	-18.65	57.11
S'	-2.08	41.51	-1.61	24.07	-1.86	28.62	-2.56	72.14	-2.44	48.93
TAPSE	-0.17	36.00	-0.07	25.96	-0.15	23.67	-0.25	66.57	-0.23	35.17

Bias is reported as mean difference (Epsilon - manual readings);
Relative difference (%) is reported as (difference /mean of two readings)*100

Poster Session 2 (P2)

Monday, June 25, 2018

Image Epsilon EchoInsight® Tracing

P2-63

Three Dimensional Speckle Tracking Parameters can Predict the Response of Cardiac Resynchronization Therapy

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Objective: Cardiac resynchronization therapy(CRT)can improve cardiac function and long-term prognosis in patients with heart failure, but there are still 30% non-responders. The possible reason is lack of optimal methods and parameters for assessing cardiac synchrony and myocardial viability to identify potential responders. A novel three dimensional speckle tracking imaging (3DSTI) can evaluate cardiac synchrony and myocardial mechanics parameters,our study aims to test the ability of 3DSTI parameters in predicting CRT response. **Methods:** Ligature in the first diagonal branch of coronary artery to create ischemic heart failure(IHF), and radiofrequency ablation to induce left bundle branch block(LBBB) were performed in 20 Beagle canines. The canines were divided into four groups: Group A(N=5): IHF+CRT; group B(N=5):IHF; group C(N=5): IHF+LBBB+CRT, and group D(N=5): IHF+LBBB. Three-dimensional longitudinal strain(sl),radical strain(sr),circumferential strain(sc) ,3D strain (s3d)),twist(tw),apical rotation(ra), basal rotation(rb) and their standard deviations time to peak values (sl-SD,sr-SD,sc-SD,s3d-SD,s3d-SD,ra-SD, tw-SD) as synchrony indexes were analyzed before after and CRT. After CRT, 5% increasing of LVEF, or 10% decreasing of LVESV were considered as responders. **Results:** Sl,sc and sr,but not the synchrony indexes were decreased in group A and B. It suggested that myocardial infarction may affect myocardial deformation more than ventricular asynchrony. S3d, sc, sl, tw and ra-SD in group C and D were decreased significantly, indicating that LBBB affect not only myocardial deformation but also ventricular asynchrony. After CRT, sl, sc, and sr were all improved but none of the synchrony index in group A and group c were changed. There were no significant differences of LVEF, sl,sr before CRT in responders and non-responders. However sc,s3d ,ra ,tw were higher than non-repsonders, and tw-SD, s3d-SD were longer than non-repsonsders. s3d before CRT was related to the response of CRT (correlation coefficient equals to 0.751,P=0.012).s3d>-23.7ml was defined as a cut—off value before CRT, the sensitivity and specificity of s3d in predicting the response of CRT are 67.1% and 76.7% respectively. **Conclusions:** s3d is an effective parameter to predict CRT response with a favorable sensitivity and specificity.

P2-64

Speckle Tracking Echocardiography Evaluate Left Ventricular Remodeling and Progression in Patients with Chronic Aortic Regurgitation and Predicts Left Ventricular Remodeling during Conservative Management and After Surgery

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Objectives: The aims of this study were to evaluate the change of geometry and myocardial function in patients by three-dimensional speckle tracking echocardiography (3D-STE) and to discuss their relationship with the conventional left ventricular (LV) parameters of systolic and diastolic function. **Methods:** A prospective study was conducted in 41 healthy volunteers and 133 patients with AR, and the AR groups were divided into three subgroups according to the degree of regurgitation. Among the AR patients, 24 randomly selected subjects underwent magnetic resonance imaging (MRI) within 48 hours. LV volumetric parameters and strain parameters were acquired by 2D-STE, 3D-STE and feature tracking magnetic resonance imaging (FT MRI). LV volumetric parameters and strain parameters were acquired and the difference of these indexes between the control and AR groups were explored. Finally, 12 patients who underwent AVR and 10 patients who not receive surgical correction with severe regurgitation were carefully evaluated by 3D-STE at 3-year follow up. **Result:** With an increasing degree of regurgitation, the measures of LV volumetric indexes and sphericity indexes gradually increased. Compared with control group, the measures of global longitudinal strain were lower, but apical rotation and Twist were larger in the moderate group. Global longitudinal strain, global radial strain, Torsion, apical rotation and Twist were lower in the severe group. Multiple linear regression analysis identified global longitudinal strain, global radial strain, and apical rotation as predictors of LV ejection fraction in all patients with AR and left atrial dimension, the end-diastolic sphericity index, LV mass index and LV remolding index as predictors of LV diastolic filling. LV volumetric indexes, sphericity indexes and stain improved in patients underwent AVR and deterioration in patients with no surgical correction during follow-up. Comparing with FT MRI and 2D-STE, the measures of volumetric parameters and strain by 3D-STE were not significant difference. **Conclusion:** The volumetric parameters and strain parameters may be related to conventional left ventricular parameters of systolic and diastolic function in patients with chronic aortic regurgitation. LV structural and functional remodeling improved actively in patients who underwent AVR and deterioration in patients who not receive surgical correction during follow-up.

P2-65

Inter-Reader Concordance from a GLS Training Exercise Persists Over a Year of Follow-Up: Lessons from the SUCCOUR Trial Core Lab

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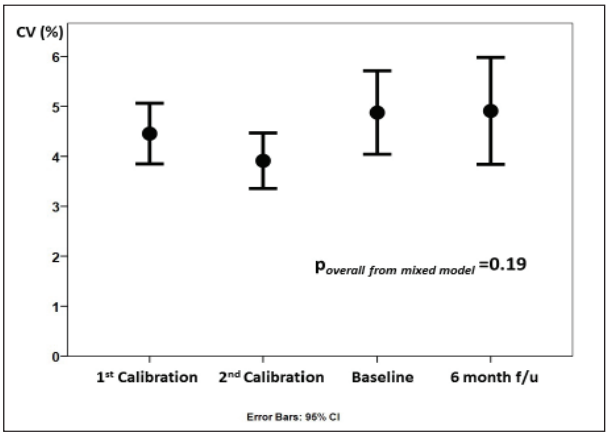
Background: Based on the greater sensitivity and lower variability of global longitudinal strain (GLS) than EF, GLS is recommended in cardio-oncology guidelines. Previous work has documented that a quality control process improves inter-observer concordance of GLS, which exceeds that of EF. However, the stability of this training over time would be valuable in both research and practice, and has not been shown. **Methods:** To standardise GLS measurement, we administered a two-stage baseline calibration session with tailored feedback to 18 independent strain readers at 17 different sites in a multi-national randomised controlled trial. This study involved the consistency of GLS between the sites and core lab (CL) over 6 month follow-up (6MFU). Coefficient of variance (CV) was used to determine concordance. **Results:** 18 readers had completed the calibration and the CV of GLS at 1st and 2nd session were 4.5±3.1% and 3.9±2.9%. In the trial, 71 patients (54±13 years, 66 female) were enrolled. The time delay between training and initial analysis was 20±23 weeks. Baseline GLS of the overall group at CL and sites (-21.1±2.4% vs -20.3±1.9%, p=0.16) decreased at 6MFU (-19.8±2.5% vs -19.3±2.6%, p=0.85). The CV of GLS at baseline and 6MFU were 4.9±3.5% and 4.9±4.5% (p=0.96). In the whole period from 1st calibration to the 6MFU, the CV was stable and did not significantly change (p=0.19) (Figure). In contrast, the CV of EF at 1st session, baseline & 6MFU were 8.5±7.2, 4.7±3.3 & 6.1±5.0%, respectively and those tended to exceed that of GLS at each time-point (1st Cal: p<0.001, baseline: p=0.78, 6MFU: p=0.07, respectively). **Conclusion:** Consistency of measurement of sequential GLS is critically important in clinical trials as well as in practice. The results of this study show that the benefits of an initial calibration process carry over to ongoing follow-up.



Poster Session 2 (P2)

Monday, June 25, 2018

P2-66

Automated Dynamic Measurement of Left Heart Chamber Volumes for Quantification of Ejection and Filling Parameters

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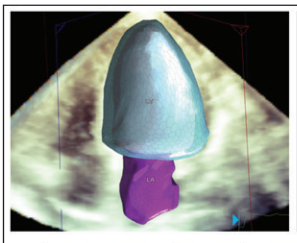
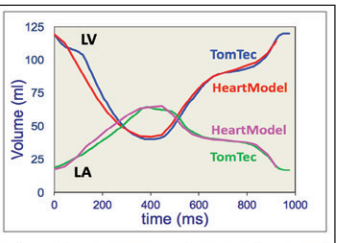
Background: Although volumetric analysis of 3D echocardiographic (3DE) datasets provides accurate and reproducible measurements of left ventricular and left atrial (LV, LA) volumes at end-systole and end-diastole, chamber volumes are usually not measured throughout the cardiac cycle because of lack of automated tools needed to allow such analysis within a reasonable timeframe. To bridge this gap and facilitate analysis of dynamic changes in chamber volumes, the recently developed 3DE adaptive analytics algorithm was expanded to analyze every frame throughout the cardiac cycle, resulting in LV and LA volume-time curves. Our aim was to validate ejection and filling parameters calculated from these curves by comparing them to those obtained using commercial 3DE volumetric analysis software. **Methods:** We prospectively studied 15 randomly selected patients who underwent 3DE imaging (Philips EPIQ, X5-1 transducer). Single-beat, high-frame rate 3DE datasets were acquired to include both LV and LA cavities. Time-volume curves were obtained for both chambers using the automated software (Philips HeartModel; figure, left) and conventional volumetric analysis (TomTec 4D LV Analysis and TomTec LA Function). LV and LA systolic and diastolic volumes and ejection and filling parameters were compared between the two analysis techniques. **Results:** Minor manual correction of the automatically detected LV and LA borders was performed in 4/15 and 4/15 cases, respectively. Time required to generate time-volume curves using the automated 3DE analysis (including manual corrections) was 35±17 sec, considerably shorter than the conventional volumetric analysis (~3-4 minutes per patient). Time-volume curves obtained by the two analysis techniques were similar in shape and magnitude in the majority of patients (figure, right). Chamber size and function parameters extracted from these curves showed no significant inter-technique differences (Table). **Conclusion:** Automated 3DE software for dynamic LV and LA volume measurement allows fast and accurate analysis of ejection and filling parameters, compared to conventional volumetric analysis. Incorporation of this algorithm into clinical workflow may provide additional insight into abnormalities in cardiac function that are not assessable by current techniques.





	Left Ventricle	TomTec	Heart Model
Ejection Indices	End-systolic volume	68 ± 25	69 ± 23
	Stroke volume	106 ± 30	97 ± 25
	Ejection fraction	61 ± 9	59 ± 9
	Volume (50% ejection time)	106 ± 32	107 ± 33
Filling Indices	End-diastolic volume	174 ± 44	167 ± 40
	Filling duration (%RR)	58 ± 7	58 ± 4
	Volume (25% filling time)	93 ± 28	91 ± 28
	Volume (50% filling time)	122 ± 33	123 ± 28
	Volume (75% filling time)	137 ± 36	142 ± 42
	Volume at diastasis	136 ± 60	133 ± 33
	Rapid filling volume	68 ± 50	64 ± 18
	Rapid filling fraction	0.63 ± 0.43	0.66 ± 0.11
	Atrial filling volume	37 ± 41	33 ± 14
	Atrial filling fraction	0.37 ± 0.43	0.34 ± 0.11

	Left Atrium	TomTec	Heart Model
Filling Indices	Maximum volume	71 ± 29	80 ± 17
	Filling duration (%RR)	55 ± 24	46 ± 7
	Filling fraction	60 ± 11	57 ± 12
	Volume (50% filling time)	59 ± 16	56 ± 15
Emptying Indices	Minimum volume	42 ± 22	34 ± 11
	Emptying duration (%RR)	45 ± 24	54 ± 7
	Volume (25% emptying time)	59 ± 23	67 ± 14
	Volume (50% emptying time)	50 ± 18	54 ± 13
	Volume (75% emptying time)	44 ± 17	50 ± 14
	Volume at diastasis	59 ± 22	52 ± 15
	Passive emptying volume	30 ± 15	27 ± 10
	Passive emptying fraction	0.63 ± 0.29	0.59 ± 0.14
	Active emptying volume	17 ± 14	19 ± 8
	Active emptying fraction	0.37 ± 0.29	0.41 ± 0.14

P2-67

Identification of Local Carotid Artery Abnormalities by Comprehensive Ultrasound Imaging in Patients with Metabolic Syndrome

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Objective: The aim of this study was to assess the feasibility and accuracy of comprehensive ultrasound Imaging in theapplication of local carotid artery abnormalities. **Methods:** Eighty-five patients with MS were divided into three sub-groups, MS with diabetes (DMS,n = 29), MS with hypertension (HMS, n = 29), MS with hypertension and diabetes (HDMS, n = 27), 24 age and gender- matched healthy volunteers were enrolled as control group(CON). In two-dimensional speckle-tracking Imaging (2D-STI), thevalues of left common carotid (LCCA)were measured:localpeak carotid arterial strains (CAS) in each of six equal segments (the anterior, left anterolateral, left posterolateral, the posterior,right anterolateral, right posterolateral wall regions) were analyzed, and averages of all segments(*i.e.*the global average); four time interval from carotid strain curve, Predistension time(PDT), Arterial distension Period(ADP), peak CAS time(PST) and arterial diastolic time(ADT). All the time indices were normalized for cardiac cycle length. Conventional E-tracking imaging wasperformed to assess the carotid stiffness. **Results:** ①Left ventricular mass index (LVMI) were increased in patients with all MS patients when compared with that in controls($P<0.05$), the ratio of E/A was decreased significantly($P<0.05$); IMT was higher in patients with MS($P<0.05$).LCCA stiffness β were increased in MS patients when compared with controls, the values were worse in HDMS patients(P =0.0001);②In patients with MS, global CAS and the CAS of the posterior and right posterolateral segments were lower when compared with those in controls (P=0.0001), CAS was further reduced in patients with HDMS compared with HMS and DMS(P=0.02).Global CAS was negatively correlated with β(r = -0.469, P =0.0001), age (r =-0.413, P =0.0001);③In patients with MS, time parameters of PST, PDT and ADP were prolonged, ADT was shorter (P=0.002);④The Bland-Altman analysis showed that the coefficient of variation (CV) of inter- and intra-observer of CAS was 5.07% and 5.40%, the CV of inter- and intra-observer of β was 7.83% and 8.92%. **Conclusions:** Carotid artery exits abnormal stiffness increase in patients with MS. CAS will further reduce with the progression of MS. Cardiac contraction and stress was delayed and carotid artery retraction time was shortened in MS patients.

P2-68

Energy Loss Index by Vector Flow Mapping as a Novel Parameter for Assessing Ventricular Efficiency

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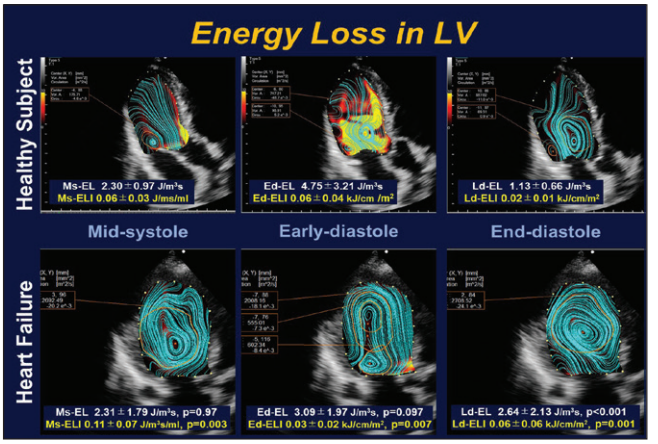
Background: Vector Flow Mapping (VFM) can measure energy loss (EL) based on color Doppler parameters and the speckle tracking technique. EL in left ventricle (LV) is produced by turbulent flow caused by increases in blood flow. Because stroke volume is decreased in patients with heart failure with reduced ejection fraction (HFrEF), we hypothesized that an index adjusted by flow rate may be an indicator of LV efficiency. The objective of this study was to test the hypothesis that EL index as EL divided by flow parameters is able to characterize HFrEF as a new marker for LV efficiency. **Methods:** Two-dimensional echocardiography including VFM was assessed in 39 healthy subjects and in 12 patients with HFrEF (LVEF < 35%). EL was calculated as lost energy per m^2 millisecond using apical long axis views. Three peaks of EL during the cardiac cycle were assessed; mid-systolic EL, early-diastolic EL and late-diastolic EL and each adjusted by flow parameters; stroke volume index for ms-EL, transmitral E wave velocity for ed-EL and A wave velocity for ld-EL, respectively. **Results:** VFM was feasible in all 51 subjects. In healthy subjects, mid-systolic, early-diastolic and late-diastolic EL were positively correlated with stroke volume index (r=0.59, p<0.001), transmitral E wave velocity (r=0.59, p<0.001), and A wave velocity (r=0.64, p<0.001), respectively. The patients with HFrEF had significantly dilated LV (66.1±11.3 vs. 45.8±4.1 mm, p<0.001), lower LVEF (24.8±5.3% vs. 66.5±4.7%, p<0.001) and reduced diastolic function (E/e': 20.0±10.3 vs. 6.8±1.6, p<0.001) compared with healthy subjects. Although simple ELs failed to show the difference between the groups in mid-systole and in early-diastole, all of the EL indices adjusted by flow were significantly different between groups: mid-systolic EL index (0.11±0.07 vs. 0.06±0.03 J/ms/ml, p=0.003), early-diastolic EL index (0.03±0.02 vs. 0.06±0.04 kJ/cm/m^2, p=0.007) and late-diastolic EL index (0.06±0.06 vs. 0.02±0.01 kJ/cm/m^2, p=0.001). **Conclusions:** EL when adjusted by flow was able to characterize HFrEF better than simple EL alone. EL by VFM has promise as a novel useful parameter for assessing ventricular efficiency.



Poster Session 2 (P2)

Monday, June 25, 2018

P2-69

Left Atrial Function is Impaired in Proportion to Severity of Mitral Stenosis in Patients with Rheumatic Heart Disease

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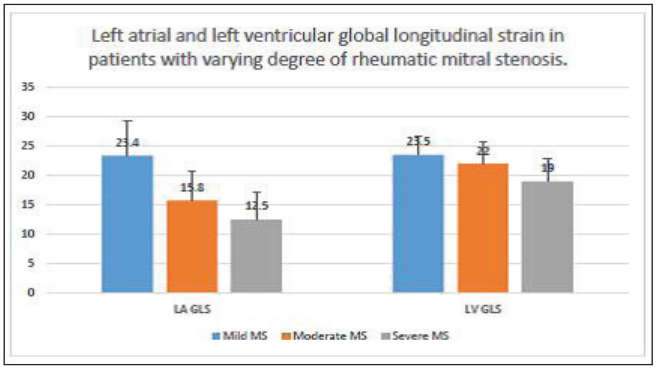
Background: Our aim of the study is to assess the effect of left atrial myocardial function with varying severity of rheumatic mitral stenosis(RMS). We hypothesized that left atrial global longitudinal strain (LA GLS) is worse with advanced rheumatic mitral valve involvement. **Methods:** Left atrial and left ventricular strain analysis was performed on rheumatic heart disease patients using 2D CPA Tom Tec Imaging systems, Germany. Apical four chamber view was used to perform measurements of strain analysis. **Results:** The mean age of the study population was 62 +/- 14.8 years and average body surface area (BSA) was 1.8 +/- 0.2. A total of 120 [Males: n=16 (13.3%), Females: n=104 (86.6%) of the cohort] patients were included in the study. We included 40 patients in each group: Group 1= Mild mitral stenosis (mean mitral gradient (MMG) : 3.9 +/-1.29), Group 2 = Moderate mitral stenosis (MMG: 7.2 +/-2.1), Group 3 = Severe mitral stenosis (MMG: 14.4 +/-5.6). Mean LA GLS and LV GLS across three groups were noted in the figure (below). Using multivariate regression analysis after adjusting for age, sex and BSA, there were statistically significant differences for LA GLS, LA end diastolic volume (LA EDV) between Group 1 vs. 2 and Group 2 vs. 3 (p <0.05). LV GLS was statistically different between Group 2 vs. 3 (p <0.05) (See table). **Conclusion:** Left atrial global longitudinal strain is worse in patients with advanced mitral stenosis. LA GLS is a sensitive parameter for the assessment of atrial function beyond LA ejection fraction (LA EF) and LA fractional area change (LA FAC). Serial evaluation of LAGLS and LV GLS may provide insight into subclinical progression of disease in patients with rheumatic mitral stenosis. Left ventricular global longitudinal strain is significantly different between moderate and severe rheumatic mitral stenosis group which may indicate effect of rheumatic disease on left ventricular function with advanced disease.

Multivariate regression analysis adjusted for age, sex and BSA				
Groups	Variable	Diff	95% CI	P-value
Mild vs. Moderate mitral stenosis	LA GLS	-7.9	(-10.3, -5.5)	<0.001
	LV GLS	-1.6	(-3.2, 0.04)	0.056
	LA EDV	28.9	(6.7, 51.0)	0.012
	LA EF	-16	(-19.6, -12.6)	<0.001
	LA FAC	-11.8	(-14.5, -9.0)	<0.001
Moderate vs. Severe	LA GLS	-3.3	(-5.5, -1.0)	0.006
	LV GLS	-3	(-4.7, -1.3)	<0.001
	LA EDV	95.7	(38.8, 152.6)	0.001
	LA EF	-2.6	(-6.9, 1.6)	0.221
	LA FAC	-2.7	(-5.8, 0.4)	0.088
All analysis were adjusted for age, sex and BSA.				



P2-70

Incremental Prognostic Value of Intraplaque Neovascularization Detected by Carotid Microbubble Contrast-Enhanced Ultrasound (CEUS) in Patients Undergoing Stress Echocardiography

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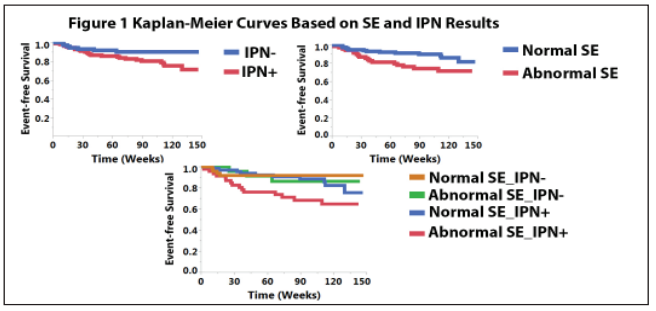
Background: Stress echocardiography (SE) is widely used for diagnosis and risk stratification of patients with known or suspected coronary artery disease (CAD). Microbubble contrast-enhanced ultrasound (CEUS) detects carotid intraplaque neovascularization (IPN), known to be associated with cardiovascular events (CVE). We hypothesized that combining SE with carotid CEUS in patients with known or suspected CAD may provide incremental prognostic information beyond clinical risk factors and either test alone. **Methods:** Patients with known or suspected CAD referred for SE and found to have carotid plaques on screening imaging were recruited to undergo CEUS, performed(GE Logic E9 9L probe) using low mechanical index (0.17-0.20) imaging during Optison infusion [1 mL slow IV bolus, repeated (0.5 mL) as needed]. IPN was graded as + (present) and - (absent) according to microbubble location and kinetics. Abnormal SE was defined as fixed or new wall motion abnormality. Patients were grouped as normal SE and IPN-, normal SE and IPN +, abnormal SE and IPN-, abnormal SE and IPN+, and followed clinically for CVEs [mortality, myocardial infarction (MI), unstable angina (UA), coronary revascularization (REVASC) and transient ischemic attack /stroke (TIA/CVA)]. **Results:** 185 patients (men 79%; mean age 69±8 years) were followed for 93±37 weeks, during which, 32 CVEs occurred (6 deaths, 9 MI, 7 UA, 7 REVASC, and 3 TIA/CVA). Of patients with CVEs, SE was abnormal in 56%; IPN + was in 78%. For clinical data and CVEs stratified by SE and IPN results see Tables 1A and 1B. The Kaplan-Meier curves of event-free survival are illustrated in Figure 1. Multivariate Cox proportional hazard analysis showed that IPN+ and CAD history were significant predictors of CVEs [hazard ratio (95% CI):2.23 (1.02-5.60), p= 0.04, 3.52(1.32-12.2), p=0.01, respectively]. **Conclusion:** The combined assessment of IPN by CEUS in patients with known or suspected CAD undergoing SE has incremental prognostic value for cardiovascular events.

Table 1 Clinical characteristics and CVEs stratified by SE and IPN results

A. Characteristics of patients (n=185) undergoing stress echo				
	Patients without IPN (n=73)		Patients with IPN (n=112)	p
Cardiovascular risk factors				
Age, yrs	70±8		69±9	0.49
Gender male (n, %)	51(70%)		95(85%)	0.02
HTN	56(77%)		91(81%)	0.46
Diabetes (n, %)	22(30%)		43(39%)	0.23
Current smokers	6(8%)		16(14%)	0.20
Lipids (mg/dL)				
Total cholesterol	158±39		165±39	0.26
Triglycerides	134±81		168±109	0.02
HDL cholesterol	51±14		46±12	0.01
LDL cholesterol	79±26		84±30	0.29
History of CVD (n, %)	48(66%)		72(64%)	0.84
Abnormal Stress echo	23(32%)		46(41%)	0.19
Ultrasound findings				
Maximum CIMT (mm)	0.85±0.15		0.90±0.16	0.06
Thickness of target plaque (mm)	3.0±1.2		3.3±1.0	0.09
B. CVEs (n=32) by SE and IPN findings				
	Normal SE		Abnormal SE	P
CVEs (n, %)	14(44%)		18(56%)	0.02
	IPN-		IPN+	P
CVEs (n, %)	7(22%)		25(78%)	0.02
	Normal SE_IPN-	Normal SE_IPN+	Abnormal SE_IPN-	Abnormal SE_IPN+	P
CVEs (n, %)	4(13%)	10(31%)	3(9%)	15(47%)	0.02

Figure 1 Kaplan-Meier Curves Based on SE and IPN Results



P2-71

Echo Contrast Use Reduces Inter-Reader Variability of LVEF Measurements in Heart Failure Patients

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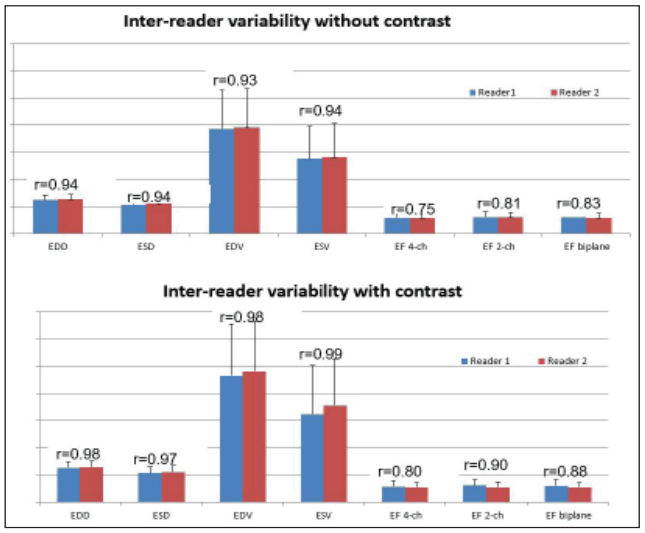
Background: Accurate evaluation left ventricular (LV) size, volumes and ejection fraction (EF) is crucial in the management of patients with heart failure (HF) and may require echo contrast use for LVEF quantitation. In this multicenter Echo Core Lab study comprising of predominantly community based practices (70%), we evaluated the prevalence of contrast use, benefit of contrast on the global study quality and impact of contrast on the accuracy between readers for LV diameters, volumes and EF. **Methods:** Baseline TTE

studies of HF patients performed prior to randomization in a cardiac resynchronization trial (Abbott) were evaluated in an Echo Core Lab. Sonographers (reader 1) performed measurements on de-identified data followed by independent re-evaluation of all data by an echo expert cardiologist (reader 2) who performed repeat LV measurements in case of disagreement with reader 1. LV end diastolic (EDD) and end systolic (ESD) dimensions and volumes (EDV and ESV) were measured to calculate LVEF in 4 chamber (4-ch), 2 chamber (2-ch) and biplane views. TTE study quality was graded as good, fair & poor. **Results:** Baseline demographics are shown in Table 1. Of a total of 363 studies contrast was administered in 37 patients (9%). Despite increased body mass index of patients with contrast, TTE study quality was "good" in 70% of contrast studies vs. 42% of non-contrast studies. EDV and ESV measured using contrast were higher by both readers, (EDV: reader 1, p=0.005, reader 2, p=0.0008), (ESV: reader 1, p=0.01, reader 2, p=0.001). Concordance (correlation of coefficient "r") for LVEF values in non-contrast apical 4-ch and 2-ch was 0.74 and 0.81 respectively between readers 1 and 2 and improved to 0.8 and 0.9 respectively with contrast. The biplane LVEF „r" improved from 0.82 without contrast to r=0.90 with contrast. **Conclusion:** Echo contrast is significantly under used in HF patients despite therapy decisions utilizing measured LVEF, contrast utilization improved study quality and concordance between readers and yielded higher LV volumes.

Table 1

Echo Studies with Contrast		
	Mean Age (yrs)	Mean BMI (kg/cm²)
Male n=26	70 (45-93)	34.9 (22.8-51.5), p=0.00008[a]
Female n=11	71 (49-84)	35.8 (20.7-45.4), p=0.003[b]
Echo Studies without Contrast		
	Mean Age (yrs)	Mean BMI (kg/cm²)
Male n=222	73 (43-93)	30.0 (16.04-50.0)
Female n=100	73 (38-99)	28.4 (16.0-51.6)

[a] vs male without contrast and [b] vs females without contrast. Two sample equal variance t test was performed.



P2-72

Monitoring of the Left Ventricular Function in Cancer Patients Using Contrast Echocardiography: When is a Change in Ejection Fraction Significant?

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Background: Contrast echocardiography has been shown to be very accurate and reproducible. However, there is limited data on what is the minimum change that can be detected in cancer patients undergoing treatment with cardiotoxic drugs who are referred for monitoring left ventricular (LV) function. **Objective:** To assess variability in the measurement of LV volumes and ejection fraction (EF) in 2-dimensional (2D) contrast echocardiography and to determine the minimum difference between two EF measurements that can be deemed significant. **Methods:** A total of 150 patients were divided into three groups according to EF (EF <53%, 53%-60%, and >60%). Each group consisted of 50 randomly selected cancer patients who underwent contrast echocardiography between July 2010 and May 2014. All patients received an ultrasound contrast agent and all studies were performed by an experienced sonographer. Repeated measurements of LV volumes and EF were performed offline by a sonographer and a cardiologist. Inter-observer variability was assessed by analysis of variance. Measurement error was estimated by standard error of measurement and minimum detectable difference (Figure 1). In order to establish clinically relevant values for the minimum detectable difference, only numbers without decimals were reported. **Results:** The 95% confidence intervals were low for EF as well as for end-diastolic volume (EDV) and end-systolic volume (ESV) in all groups (Table 1). The minimum detectable difference for EF, EDV and ESV that could be recognized with 95% confidence were 4 percentage points, 7 mL and 4 mL, respectively. **Conclusion:** Contrast 2D echocardiography is an accurate tool for serial measurement of LV function. In patients with normal or mildly reduced EF, a minimum change in EF of ≥4 percentage points on a good quality recording is likely to represent a real change in LV function.

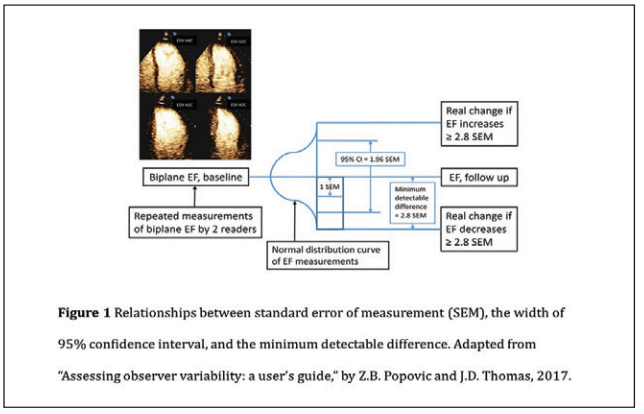

Figure 1 Relationships between standard error of measurement (SEM), the width of 95% confidence interval, and the minimum detectable difference. Adapted from "Assessing observer variability: a user's guide," by Z.B. Popovic and J.D. Thomas, 2017.

Standard error of measurement (SEM) and minimum detectable difference (MDD) for LV volumes and EF

EF	EDV SEM (mL)	ESV SEM (mL)	EF SEM (%)	EDV MDD (mL)	ESV MDD (mL)	EF MDD (%)
<53%	2.5	1.4	1.1	7	4	3
53%-60%	2.6	1.1	1.3	7	3	4
>60%	2.0	1.2	1.1	6	3	3

P2-73

Therapeutic Flow Augmentation in Muscle in Response to Microbubble Cavitation is Influenced by Ultrasound Pulse Duration

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Background: Ultrasound (US) can increase tissue perfusion. The presence of gas-filled microbubble (MB) contrast agents markedly augments this effect through shear-dependent endothelial signaling during MB cavitation. Long pulses of US at high mechanical index (MI) have been shown to produce sustained inertial cavitation of MBs, which could further increase the therapeutic effect of US for ischemic disease. We hypothesized that skeletal muscle flow augmentation during MB cavitation would increase with US pulse duration. **Methods:** In wild-type mice, the hindlimb skeletal muscle unilaterally was exposed to US for 10 min after I.V. injection of $2x10^8$ lipid-shelled MBs. US (1.3 MHz) was performed at pulsing interval of 5 sec with a programmable phased-array probe at an MI of 1.5 and low line density of 16 lines at 4 degree increments. US was performed using short pulse (5 cycle), long pulse (40 cycle), or long multipulse (5 cycle, 8 repetitions in a "power Doppler" scheme) exposures. To assess the effect of cavitation, low-MI contrast enhanced ultrasound (CEU) perfusion imaging, which does not influence blood flow, was performed in the US-exposed limb and the contralateral non-exposed control limb. **Results:** Muscle microvascular blood flux rate (β) in the control limbs was similar for US given with short, long, and long multi-pulse pulse sequences (0.25 ± 0.08 vs 0.23 ± 0.04 vs 0.18 ± 0.04 s^{-1}, p>0.99). The short 5-cycle pulse length produced a non-significant 1.7-fold increase in β compared to the control limb (0.25 ± 0.08 vs 0.41±0.09 s^{-1}, p=0.1330). The long single pulse sequence resulted in a 3.7-fold increase in β (0.23 ± 0.04 vs 0.85 ± 0.17 s^{-1}, p<0.0001) and the long multipulse sequence produced a 3.2-fold increase (0.18 ± 0.04 to 0.54 ± 0.22, p<0.0001), compared to control. The degree of flow in the US-exposed limb was significantly greater (p<0.01) with long single pulse US than with short pulse or multipulse US sequences. **Conclusion:** The degree of flow augmentation that occurs in response to MB cavitation during high-MI US is influenced by pulse duration and pulse segmentation. These data indicate that sustained MB inertial cavitation is likely to be most effective at producing shear-dependent changes in resistant microvascular tone, and that brief duration of therapy (10 min) can produce large increases in muscle perfusion that may be helpful in ischemic peripheral artery disease.

Poster Session 2 (P2)

Monday, June 25, 2018

P2-74

Augmentation of Left Ventricular Systolic Function with Intravenous Microbubbles and Intermittent High Mechanical Index Impulses in Patients with Normal Left Ventricular Systolic Function vs. Depressed Left Ventricular Systolic Function Compared to Patients Post STEMI

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Background: During an intravenous commercially available microbubble infusion, intermittent high mechanical index (MI) impulses from a transcutaneous diagnostic transducer have been shown to augment skeletal muscle blood flow via a purinergic signaling pathway. It is unknown what effect transthoracic diagnostic high MI impulses have on left ventricular (LV) ventricular systolic function and in those post STEMI patients receiving ultrasound enhancing agents (UEAs) and intermittent high MI impulses for diagnostic assessments of regional function and left ventricular ejection fraction (LVEF). **Methods:** We independently measured LV end diastolic (EDV), end systolic (ESV) using a Method of Discs algorithm, and computed LVEF before and after at least two high MI impulses (0.9-1.1 MI; five frames) in the same apical window. Patients with atrial or ventricular arrhythmias at any time during the resting measurement period were excluded. Patients were sub-divided into those with normal resting LVEF (55% or greater) and depressed resting systolic function. All measurements were obtained during either 3% Definity (Lantheus Medical) of following 0.5 ml slow bolus injections of Lumason (Bracco Diagnostics). **Results:** A total of 70 patients referred for resting echocardiograms to evaluate LV systolic function were examined (mean age 63+/-10 years; 38 normal LVEF, 32 abnormal LVEF in which 18 patients post STEMI were included with). There were no differences between the two groups with respect to age, gender, or cardiac risk factors. LVEF did not change after high MI impulses in the normal LVEF group (59+/-4% before to 61+/-6% after high MI impulses but did increase significantly in the abnormal LVEF group (42+/-12% before to 46+/-15% after; p=0.0003). This was mediated primarily by a reduction in LVESV (p=0.004) without affecting LVEDV, indicating the high MI impulses augmented contractility in this sub-group. **Conclusions:** During a commercially available microbubble administration, intermittent high MI impulses from a diagnostic transducer appear to at least transiently augment contractility in patients with depressed systolic function whether post STEMI or not. The duration of this effect and potential for therapeutic benefit needs to be explored.

P2-75

Cardiomyocyte-Targeted and 17β-Estradiol-Loaded Acoustic Nanoprobes as a Theranostic Platform for Cardiac Hypertrophy

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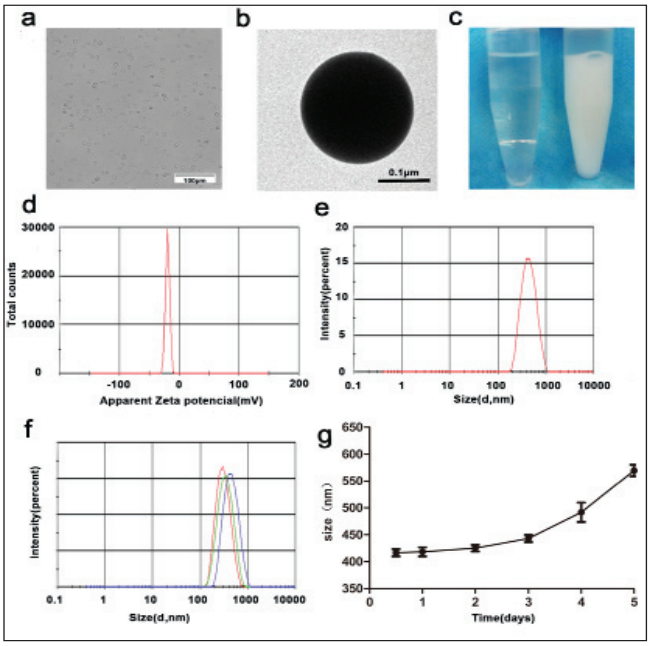
Background: Theranostic perfluorocarbon nanoprobes have recently attracted attention due to their fascinating versatility in integrating diagnostics and therapeutics into a single system. Furthermore, although 17β-estradiol (E2) is a potential anti-hypertrophic drug, it has severe non-specific adverse effects in various organs. To overcome these limitations, we have developed cardiomyocyte-targeted theranostic nanoprobes to achieve concurrent targeted imaging and treatment of cardiac hypertrophy. **Methods:** E2-loaded, primary cardiomyocyte (PCM) specific peptide-conjugated nanoprobes with perfluorocarbon (PFP) as a core (PCM-E2/PFPs) were prepared by double emulsification evaporation method combined with carbodiimide method. Then the physical properties, the ability of imaging of the nandroplets in vitro and in vivo were assessed upon low-intensity focused ultrasound (LIFU). Meanwhile the distribution of PCM-E2/PFPs in vivo and therapeutic effect with LIFU irritated on cardiac hypertrophic rats were evaluated. **Results:** We had successfully synthesized PCM-E2/PFPs and demonstrated their stability and homogeneity. In vitro and in vivo studies confirmed that when exposed to LIFU, these versatile PCM-E2/PFPs can be used as an amplifiable imaging contrast agent. Furthermore, the significantly accelerated release of E2 enhanced the therapeutic efficacy of the drug and prevented systemic side effects. PCM-E2/PFPs + LIFU treatment also significantly increased cardiac targeting and circulation time. Further therapeutic evaluations showed that PCM-E2/PFPs + LIFU suppressed cardiac hypertrophy to a greater extent compared to other treatments, revealing high efficiency in cardiac-targeted delivery and effective cardioprotection. **Conclusion:** Our novel theranostic nanoplatform could serve as a potential theranostic vector for cardiac diseases.



P2-76

Ultrasound Mediated Microbubble Cavitation Improved Local Blood Flow in Acute Rat Limb Ischemia and its Mechanism

Juefei Wu, Shifeng Qiu, Danxia Li, Qian Feng, Yuegang Wang, Jiancheng Xiu, Daogang Zha. Southern Medical University, Nanfang Hospital, Guangzhou, China

Background: The effect of ultrasound-mediated microbubble cavitation has been demonstrated in animal models that it can increase blood perfusion partly in the irradiated area of limbs or myocardial ischemia. A series of relevant studies have demonstrated that the mechanism of it was through the molecular pathways such as nitric oxide (NO) pathway and ATP pathway. However, most of the previous studies focus on the chronic ischemia model. In this study, acute rat hindlimb ischemia model was established in order to study the effects of intermittent high mechanical index impulses combined with intravenous infusion of microbubbles on the perfusion of tissue acute ischemia and its underlying mechanism. **Methods:** A rat model of acute hindlimb ischemia was established by unilateral ligation of the external iliac artery. Rats were randomly divided into three groups. Exposure to intermittent ultrasound alone group(1.3 MHz, mechanical index 1.3) (US alone), microbubbles alone group (2×10^8 ,IV) (MB alone), or intermittent high mechanical index impulses combined with lipid microbubbles infusion group (US+MB), each treatment time were 10 minutes. Contrast ultrasound perfusion imaging for both hindlimb were performed at the immediate, 5 minutes, 10 minutes, 15 minutes, 20 minutes and 25 minutes after treatment, respectively. By inhibiting endothelial nitric oxide synthase (eNOS), the role of NO pathway on increasing blood flow partly in acute ischemia tissue was evaluated. **Results:** The perfusion of ischemia hindlimb was significantly increased in the three groups ($P<0.05$). The perfusion in the US+MB group was the most significantly increase and closed to or even restored perfusion (Figure 1). The acute effect of acoustic-assisted perfusion was most significant immediately after treatment ($P<0.05$), and lasting for 15 minutes ($P<0.05$), and almost disappeared after 20 minutes. Inhibitory studies have indicated that NO pathway is a critical mediator of flow augmentation partly in acute ischemia tissue ($P<0.05$). **Conclusions:** Ultrasound-mediated microbubble cavitation can increase tissue blood perfusion partly in the irradiated area of acute ischemia tissue. These effects work immediately and can reverse hindlimb acute ischemia in rat for 15 minutes. The NO pathway is also a critical mediator of the acute effect of acoustic-assisted perfusion.

P2-77

Using Less Definity® Results in More Optimal Echocardiograms

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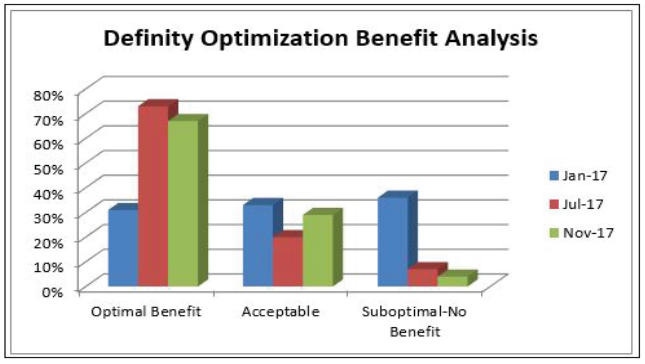
Background: Spectrum Health Cardiovascular Imaging performs over 47,000 echocardiograms annually. Many utilize the imaging agent Definity® to enhance interpretation. Quality analysis of these studies found that 36% of Definity® exams we considered suboptimal due to poor optimization or attenuation. The American Society of Echocardiography guidelines for contrast usage were reviewed, and a study was

implemented to decrease the initial dosage of Definity® and devise targeted education information. The study goals were to determine if smaller doses of Definity® and education would reduce the percentage of suboptimal studies, augmenting physician interpretations, and thus improving patient outcomes. **Methods:** An education program for staff involved with Definity® usage was implemented. According to American Society of Echocardiography guidelines sonographers were provided education for machine setting optimization. Registered nurses who administer Definity® received education about the physics of microspheres and how quantity and speed of injection can impact image quality. A smaller bolus of Definity® was reduced from 2 ml, according to manufacturer guidelines, to .5 ml or 1 ml and slower injection to allow for more uniform filling. After six months, quality analysis was repeated and studies were divided into three categories - optimal, acceptable and suboptimal. Additional analysis was reviewed during the next six months, tracking continued improvement in image quality. **Results:** Prior to implementation of staff education, 31% of echoes were considered optimal, 33% were considered acceptable and 36% suboptimal. After six months of applying education to practice, the first analysis demonstrated 73% optimal studies, 20% acceptable and 7% suboptimal. The next six months, 67% were optimal, 29% acceptable and 4% suboptimal. The changes to the Definity® administration process resulted in an 80% reduction in suboptimal studies and a 100% rise in optimization. **Conclusion:** Tailored education and reducing the dose of Definity® given with a slower injection time significantly improved the administration and optimization skills of staff. These improvements provide the reading physicians with more complete information on which to base clinical decisions.



P2-78

Follow up of Leak Status Post Watchman Device

Paraskevi Koutrolou-Sotiropoulou, Vidhu Anand, Didem Oguz,, Kashish Goel, Jeremy J. Thaden, Vuyisile T. Nkomo, Paul A. Friedman, Sorin V. Pislaru, David R. Holmes. Mayo Clinic, Rochester, MN

Background: Left atrial appendage occlusion with the Watchman device is increasingly used. Peridevice leak (PDL) is well recognized, but its long-term evolution is unknown. We set forth to evaluate the presence and severity of PDL over time and its impact on outcomes. **Methods:** Patients who underwent Watchman implantation from 2004 to 2017 (N=105, median follow up 1.2 years) were divided in patients with (Group A; N=56) and without PDL (Group B, N=49). TEE at implantation and 45 days was available in all patients; follow-up TEE at ≥ 1 year in 35/56 (63%) in Group A and 29/49 (59%) in Group B. The change in leak severity was assessed on digitally stored images; PDL worsening was defined as an increase ≥ 3 mm. Death, stroke and duration of anticoagulation were reviewed from the electronic medical record. **Results:** Mean age was 79 in both groups, 64.3% were males in Group A and 63.3% in Group B. PDL was identified on follow up at 45 days in 25/56 (44.6%); only 7/56 patients had PDL >= 5mm. PDL was unchanged on subsequent TEE in 83.9% and worsened in 16.1%. In Group A 83.9% of patients stopped anticoagulation at 45 days and in group B 77.6% (**Table**). Duration of anticoagulation was independent to the development of a leak (p=0.208). Death occurred in 4/56 in Group A 6/49 in group B (p=0.738). Three strokes occurred in Group A within first year post implantation; all 3 patients were off anticoagulation. PDL was large (circumferential) in 1 patient and small (2mm and 3.5mm respectively) in 2. There were no strokes identified in Group B. **Conclusions:** Majority of peri-device leaks remain stable over time despite cessation of anticoagulation in the majority of patients. A small number of patients with residual leak experience stroke within the first year while off anticoagulation. The size of the leak however does not seem to correlate with the occurrence of stroke.

Table

	Group A (n=56)	Group B (n=49)
Anticoagulation		
Stopped Coumadin at 45 days	47/56 (83.9%)	38/49 (77.6%)
Stopped Coumadin at <45 days	2/56 (3.6%)	4/49 (8.2%)
On Coumadin indefinitely	0/56 (0%)	1/49 (2%)
Continued Coumadin for >45 days/Coumadin restarted	6/56 (10.7%)	4/49 (8.2%)
No coumadin (only dual antiplatelet agents)	1/56 (1.8%)	2/49 (4.0%)
Events		
Death	4/56 (7.1%)	6/49 (12.2%)
(unknown,cancer, respiratory failure)		
Stroke	3/56 (5.4%)	0/49 (0%)

P2-79

Acute Hemodynamic Effects and Right Ventricular Functional Changes Following MitraClip Implantation

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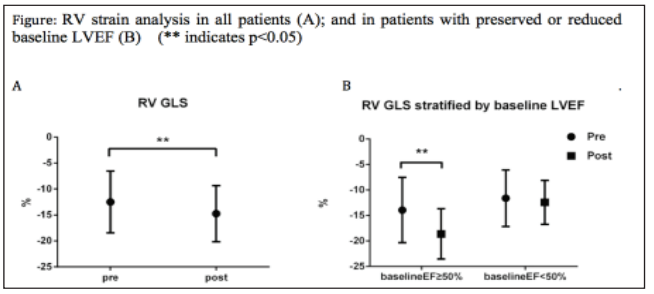
Background: Transcatheter mitral valve repair has been established as a new option to treat patients with significant mitral regurgitation (MR) and high surgical risk. The goal of this study was to assess the immediate hemodynamic effects and the right ventricular functional changes after the MitraClip (MC) procedure. **Methods:** Consecutive sixty-two patients with moderate to severe or severe MR who received MC implantation in a single-center between 2012 to 2017 were included. Right heart catheterization was performed before and immediately following MC procedure. Volumetric and functional changes were assessed using two-dimensional transthoracic and speckle-tracking echocardiography before and one day after MC procedure. **Results:** The median age was 84 (78-87) years and 47% were men. A majority of the patients had functional class NYHA III or IV (82%). The baseline left ventricular ejection fraction (LVEF) was 47 (40-54)% and MR etiology was degenerative in 87% of patients. Significant reduction in mitral regurgitation was achieved by repair in 94% patients and the mean transmitral pressure gradient increased from 2.2±1.0mmHg to 4.1±1.9mmHg (p<0.001). Immediately post MC implantation, the pulmonary capillary wedge pressure (PCWP) decreased from 22±7mmHg to 19±6mmHg (p<0.001) and the cardiac index (CI) increased from 3.9±1.9 to 5.0±1.6 L/min/m^2 (p<0.001). The right ventricular fractional area change increased from 33±12 % to 37±11 % (p=0.004) one day after MC. Significant improvement was seen in RV global longitudinal strain (-12.7±6% vs. -14.9±5%, p=0.009), which was only seen among those with preserved baseline LVEF (-14.7% vs. -17.9%, p=0.003), but not those with reduced LVEF (-10.7% vs. -12.1%, p=0.407). **Conclusions:** Successful MV repair with the MitraClip system results in an immediate and significant improvement in PCWP, CI, and RV function, particularly in those with preserved baseline LVEF. Long term follow up data will be required to assess the prognostic impact of the evolution of the right ventricular function.



P2-80

Description of Mitral Valve Repair Technique: Comparison of TEE Images and Surgical Field

Satoru Fujii, Michael W.A. Chu, Jian Ray Zhou. Western University, London, ON, Canada

Background: Degenerative mitral valve (MV) disease is the most common organic MV pathology. Recently, the American correction technique is garnering attention. In this technique, functional restoration of the MV is achieved using artificial chordae and a flexible annuloplasty ring. In many institutions, the cardiac surgeon base the length of neo-chordae on intraoperative anatomic measurements made in the open, empty, and arrested heart. At our centre, the cardiac surgeon creates chords based on echocardiographic measurements made in the functionally beating heart. In this case series, we studied the surgical technique in detail to better understand the key echo measurements that support successful repair. **Methods:** We obtained 2-dimentional and 3-dimentional transesophageal (TEE) images of the mitral valve and left ventricle in 6 patients undergoing mitral valve repair. We also collected the corresponding surgical repair videos. On echocardiogram we made multiple measurements of the

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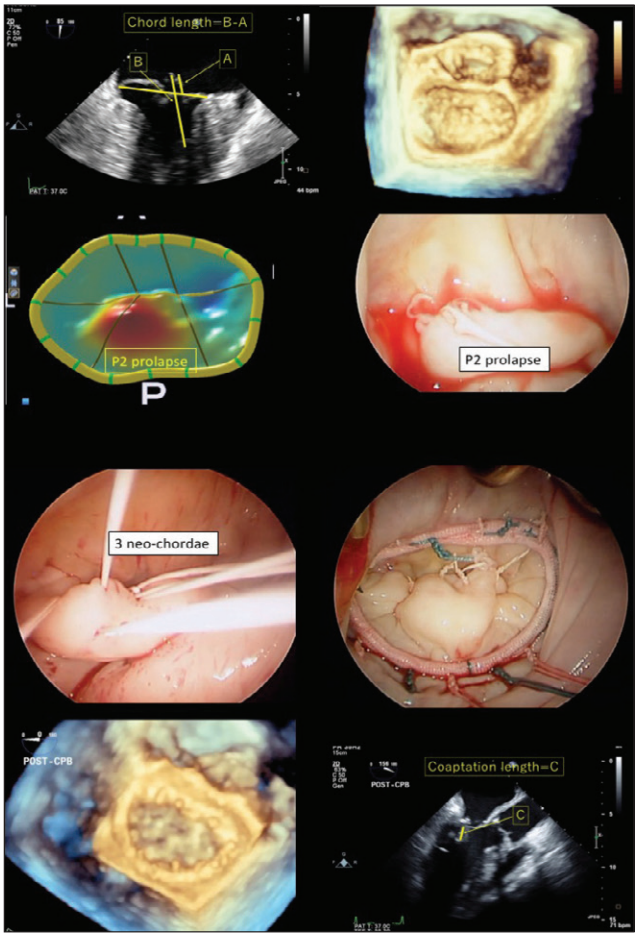
MV apparatus. The surgeon then made neo-chordae and implanted them based on the echo assessment. After the heart was restarted and volume-loaded, the mitral valve and apparatus were re-measured. Subsequently, the surgical repair videos were reviewed with the intraoperative TEE images to identify the key echo measurements helpful in guiding surgical repair. **Results:** Based on 6 patients, we found TEE facilitated excellent surgical repair and were very accurate in guiding the creation of neo-chords of the appropriate length. We also identified several key measurements that guided successful MV repair: (1) length of leaflets, (2) location of prolapse, (3) distance of annular plane to papillary muscle, (4) annular dimensions and (4) post-repair coaptation length >8 mm (fig 1). **Conclusion:** Neochords measured out by echocardiography are more "true to life" because the measurements are made in a filled heart in the systolic phase of the cardiac cycle. Echocardiography-based measurements also allow for neo-chordae creation prior to establishment of cardiopulmonary bypass (CPB), allowing for shorter bypass times and fewer CPB-related complications. 2D and 3D echocardiography will play an increasingly important role in mitral valve repair surgery with the widespread adoption of the American mitral valve correction technique.



P2-81

Radiation Doses to Physicians Performing Transesophageal Echocardiography During Percutaneous Mitral Valve Clip Procedures

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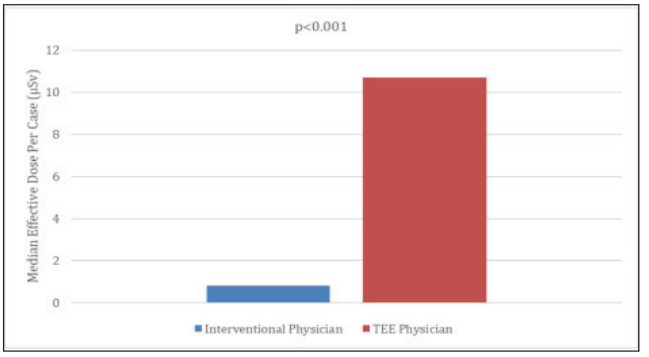
Background: The use of transesophageal echocardiography (TEE) to guide percutaneous mitral valve clip procedures requires the TEE physician to stand in close proximity to the patient. Consequently, we hypothesized that TEE physicians may receive significantly greater radiation doses than interventional physicians during percutaneous mitral clip procedures. **Methods:** Real-time radiation doses were prospectively collected by dosimeters worn by interventional physicians and TEE physicians during percutaneous mitral clip procedures. Physicians were blinded to the radiation data for the duration of the study. Dosimeter data were used to calculate and compare the effective dose per case for interventional physicians and TEE physicians. **Results:** During 30 consecutive percutaneous mitral valve clip procedures, the median effective radiation dose per case was 0.8 [0.0, 12.1] μSv among interventional physicians and 10.7 [2.8, 20.9] μSv among TEE physicians, representing a 13.4-fold greater radiation dose to TEE physicians ($p<0.001$). Among the 30 cases, the interventional physician received an effective dose >20 μSv in only 2 (6.7%) cases, whereas the TEE physician received an effective dose >20 μSv in 9 (30.0%) cases ($p = 0.02$). **Conclusions:** In the present study, which to our knowledge is the first to examine the radiation doses to TEE physicians during percutaneous mitral clip procedures, TEE physicians were observed to have a median radiation dose that was 13-fold greater than those of interventional physicians during the same procedures. These findings seemingly indicate a previously unrecognized occupational risk faced by TEE physicians in the catheterization laboratory.



P2-82

Interventional Echocardiography Performed in the Cardiac Catheterization Laboratory is Associated with Safe Levels of Radiation Exposure

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Background: The evolution of percutaneous structural heart interventions combined with the advancement of 3D-echocardiography has led to increased utilization of real-time echocardiographic guidance to complement traditional fluoroscopy. As a result, sonographers and echocardiographers are spending more time in the cardiac catheterization laboratory. This project aimed to measure the radiation exposure for ultrasound imagers performing imaging guidance with transthoracic echocardiography (TTE) or transesophageal echocardiography (TEE) during interventional cardiology procedures. **Methods:** DMC-3000 (Mirion Technologies, USA) radiation dosimeters were worn on the front and back of ultrasound imagers during consecutive interventional procedures at Mayo Clinic (Rochester, MN) from October 2017 to January 2018. DMC-3000 continuously records radiation data that can be documented immediately post-procedure. Imagers adhered to institutional radiation precautions by wearing protective lead and using mobile barriers. **Results:** 137 cases were completed during the assessment period (Table 1). The majority of structural heart procedures were TAVR using TTE guidance (N=45). Mitral valve and atrial appendage procedures used TEE guidance. Overall, TEE imaging was associated with a statistically higher radiation exposure than TTE ($p<0.001$). Mitral valve PVL was the procedure with highest mean radiation exposure. After eliminating non-structural heart procedures TEE was still associated with 3-fold higher median radiation exposure (0.018 mGy versus 0.005 mGy, $p<0.001$). For TTE guidance, 92% of the sonographer exposure was recorded by the dosimeter on the anterior chest whereas with TEE guidance 56% of the radiation exposure was recorded with the dosimeter worn on the back. There was poor correlation between the sonographer and patient recorded dose ($R^2=0.18$). Using this data it would take about 500 TTE or 120 TEE procedures to accumulate the average annual effective dose of an interventional cardiologist at our institution (~ 1.2 mSv). **Discussion:** Our data suggests that echo guidance is associated with safe levels of radiation exposure. Adequate protective lead and optimal positioning of the dosimeter is important; during TEE guidance the majority of radiation dose was to the imager's back.

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TABLE 1 RADIATION EXPOSURE (mGray)

Cases	TTE	TEE	TTE + TEE
Total Mean ± SD Median [Range]	N= 107 0.016 ± 0.035 0.006 [0.001 – 0.311]	N= 30 0.034 ± 0.045 0.017 [0.001 – 0.184]	N= 137 0.022 ± 0.043 0.008 [0.001 – 0.311]
Transcatheter Aortic Valve Replacement (TAVR)	N=45 0.017±0.031 0.006 [0.001 – 0.184]	N=1 0.049	
Aortic Valve Paravalvular Leak (PVL)	N=4 0.007±0.009 0.003 [0.001 – 0.200]		
Mitral Valve Paravalvular Leak (PVL)		N=7 0.089±0.080 0.055 [0.116-0.248]	
Mitral Valve-in-Valve (MVIV)		N=4 0.047±0.074 0.013 [0.005 -0.1581]	
Transcatheter Mitral Valve Repair (TMVR)		N=8 0.020±0.011 0.018 [0.007 – 0.037]	
Left Atrial Appendage Occlusion		N=9 0.060±0.100 0.015 [0.001-0.311]	
ETOH Septal Ablation	N=3 0.009±0.013 0.003 [0.001-0.018]		
RV Biopsy	N=52 0.011±0.014 0.006 [0.001 – 0.074]		
Balloon Mitral Valvuloplasty	N=1 0.010		
Exercise Study	N=3 0.0144±0.013 [0.001-0.029]		

P2-83

An Echocardiographic Scoring System to Evaluate the Complexity of Mitral Valve Repair - The Future of the Preoperative Work-Up

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This study sought to demonstrate that a transesophageal echocardiography (TEE)-derived mitral valve complexity score correlates with the previously published surgically-derived complexity score, thereby establishing TEE as a feasible imaging modality for stratification of mitral valve repair (MVR) complexity. **Methods:** A complexity surgical scoring system based on anatomical characteristics was previously described (Adams, 2016). Briefly, a weighted score was assigned to each valve based on the components (Table 1) and subsequently categorized into 3 groups: simple, intermediate, and complex. A total of 200 TEE examinations were retrospectively rated by two independent cardiac anesthesiologists. The valves were scored using the same anatomic variables and then correlated with the surgical scores. In addition, 50 of the 200 TEE exams were analyzed by both raters. **Results:** The surgical complexity mitral valve score was previously shown to correlate with surgical technical complexity (Adams 2016). The TEE complexity score was calculated for the same patients and demonstrated moderate correlation to the surgical scores (Pearson 0.52, Spearman 0.63, and Kappa 0.51). Additionally, preliminary analysis suggested that simple and complex TEE scores correlated better to the surgical scores than intermediate scores. Finally, the subset of cases tested for interrater variability was found to be moderately correlated (Kappa 0.52). **Conclusions:** Preliminary analysis revealed the TEE mitral valve scoring system to be moderately correlated with previously published surgical complexity scoring system for degenerative mitral valve disease (Adams 2016). Thus, feasibility of the use of TEE-derived mitral valve complexity scores to stratify degenerative MVR complexity is suggested. Furthermore, such TEE scoring may allow for effective stratification of MVR complexity in the preoperative, rather than intraoperative, setting. Additional analysis is required to assess for interrater reliability and detailed training in the use of the scoring system may be required to reduce variability amongst echocardiographers. Finally, prospective studies are needed to validate the use of TEE in predicting intraoperative surgical complexity and its practical application in the stratification of degenerative MVR.

TABLE 1. Calculating the complexity score

Complexity variable	Weight
Segment prolapse	
P1	1
P2	1
P3	1
A1	2
A2	2
A3	2
Anterolateral commissure prolapse	2
Posteromedial commissure prolapse	2
Any leaflet restriction	2
Papillary muscle or leaflet calcification without annular involvement	2
Annular calcification	3
Previous mitral valve repair	3

Complexity score = sum of weights. Complexity strata (by complexity score): Simple: 1; Intermediate: 2-4; Complex: ≥5.

P2-84

Bleeding Risk of Transesophageal Echocardiogram in Patients with Esophageal Varices: A Case Series and Systematic Review

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Background: The presence esophageal varices is a relative contraindication to transesophageal echocardiography (TEE). We present a single center case series to assess the bleeding outcomes of patients who underwent TEE with esophageal varices, followed by a systematic review literature addressing the study question. **Methods:** A single center, retrospective review was performed of electronic records from January 2006 to December 2016 for all patients who underwent TEE and esophagogastroduodenoscopy (EGD) within one year. Patients' charts were reviewed for presence of esophageal varices. TEE related gastrointestinal (GI) bleeding outcomes were tabulated. A systematic review of English articles using PubMed and EMBASE was performed for studies published between 1971 and 2017. Search terms were TEE, esophageal varices, bleeding and TEE complications. Studies that reported bleeding events from TEE, in addition to the present case series, were included in a pooled analysis. **Results:** Case Series: We identified 20 patients (mean age, 57 ± 11; 80% men) who underwent TEE with a prior or subsequent diagnosis of esophageal varices on EGD. The median time gap between EGD and TEE was 30 days. Out of the 20 patients, 18 were successfully discharged without change in hemoglobin level or overt GI bleeding. One patient went to hospice care for end-stage liver disease, and another had a prolonged in-hospital course without significant reduction in hemoglobin. Systematic Review: Seven series (n=962), including our own, met the inclusion criteria. Four series investigated patients who underwent TEE for hemodynamic monitoring during orthotropic liver transplantation surgery. Infective endocarditis work-up was another common indication. The severity of liver disease, as estimated by the mean model for end-stage liver disease (MELD) score, was 25, with a weighted mean platelet count of 77.8 x 10^3/μL and INR of 1.87. Fourteen patients (incidence, 1.45%; 95% CI, 1.41%-1.49%) had a reduction in hemoglobin level or overt GI bleeding after TEE. Events were primarily driven by one study, the exclusion of which resulted in a bleeding risk of 0.56% (95% CI, 0.56%-0.57%). **Conclusion:** The risk of bleeding from TEE in patients with esophageal varices appears to be low. Controlled studies or large registries may be needed to confirm this finding.

AUTHORS	YEAR	SETTING	COUNTRY	STUDY DESIGN	No. OF PATIENTS	INCIDENCE OF BLEEDING	LARGE VARICES	Platelet count (x1000/μL)	INR	MELD score
Burger-Kelpp et al	2012	Intraoperative	Vienna, Austria	Case series	287	0.35%	54%	78	(PT=51sec)	16
Myo Bui et al	2015	Intraoperative	Los Angeles, USA	Case series	433	2.54%	n/a	66	1.9	32
Pai et al	2015	Intraoperative	Jacksonville, USA	Case series	161	0.62%	29%	93	1.9	n/a
Pantham et al	2013	Consult-based	Cleveland, USA	Case series	24	0%	37%	142	n/a	15
Spier et al	2009	Consult-based	Madison, USA	Case series	14	0%	42%	157	1.6	18
Surlani et al	1996	Intraoperative	New York, USA	Case series	23	4.35%	n/a	n/a	n/a	n/a
Nigatu et al	2018	Consult-based	Chicago, USA	Case series	20	0%	15%	89.6	1.4	18

Table 1. Summary of Study Findings

P2-85

Intra-Procedural TEE During TAVR does not Prolong Length of Stay

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Background: It is often argued that routine use of intra-procedural transesophageal echocardiography (TEE) with general anesthesia during transcatheter aortic valve replacement (TAVR) unnecessarily prolongs inpatient length of stay and, as a consequence, negatively impacts cost of care. However, TEE may facilitate early detection of complications, impacting management and ultimately improving patient outcomes. **Methods:** To test the hypothesis that short lengths of stay can be reliably achieved

with an approach that routinely uses intra-procedural TEE and general anesthesia in the context of TAVR care pathways that emphasize early ambulation, we performed a retrospective review of 396 consecutive commercial TAVR patients from Sept 1, 2016 to September 30, 2017 in which general anesthesia and TEE were performed in all patients for whom there was no esophageal pathology or other contraindication to TEE (99.2%). Other aspects of the care pathway included early endotracheal extubation in the operating room, avoidance of urinary catheters and early ambulation. **Results:** There were 396 pts, aged 82±9y, 51% women. Median length of stay was 2 days (mean 1.9 days). The majority of patient (69%) were discharged home, mortality at 30 d was 0.7% and 30 d readmissions were 11% vs. national averages of 52%, 1.8% and18% respectively. 62% of patients were out of bed within 8 hours of their procedure. There were no TEE complications. TEE observations impacting management included confirmation of annular sizing, assessment for need to pre-dilate, detection of morphologic features which would necessitate coronary protection, detection/quantitation of new/worsening aortic and mitral regurgitation and their pathophysiology, confirmation of correct valve position prior to deployment, monitoring shifting calcific nodules distorting annular and aortic root anatomy and posing risk of rupture, early detection of annular rupture or peri-aortic hematoma, assessment of ventricular function, and detection/quantitation of paravalvular regurgitation. **Conclusions:** In the context of a program that emphasizes early extubation, early ambulation and avoidance of urinary catheters, intra-procedural TEE is not associated with excessive length of stay and may contribute to favorable outcomes in TAVR including mortality and readmission rates that are below national benchmarks.

P2-86

Radiation Exposure to Sonographers During Transesophageal Echocardiography-Assisted Fluoroscopically-Guided Structural Heart Interventions

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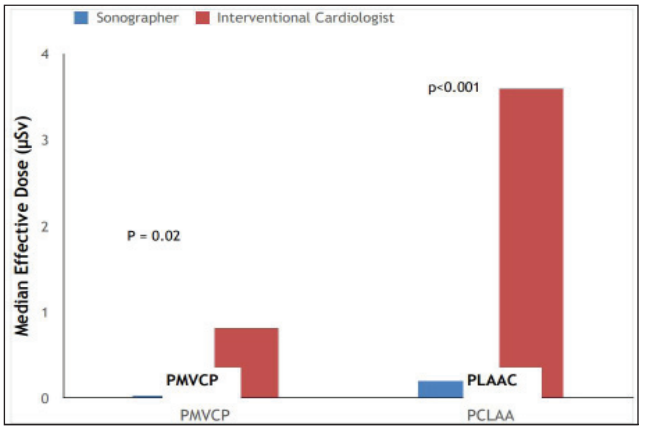
Background: Chronic exposure to occupational radiation has been associated with adverse health effects among interventional cardiologists. Radiation exposure to sonographers is becoming increasingly common as their participation in transesophageal echocardiography-assisted fluoroscopically-guided procedures (TEEFPs) expands. The level of exposure to sonographers during TEEFPs has not been adequately studied. The present study was performed to document the radiation doses received by sonographers during structural heart interventions and to compare the doses to those received by interventional cardiologists during the same procedures. **Methods:** We collected real-time radiation exposure data on sonographers and interventional cardiologists during percutaneous left atrial appendage closures (PLAACs) and percutaneous mitral valve clip procedures (PMVCPs) performed at a single center. Physicians and sonographers were blinded to the radiation data for the duration of the study. Dosimeter data were used to calculate and compare the effective dose per case for sonographers and interventional cardiologists. **Results:** During 30 consecutive PLAACs, the median effective dose per case was 0.2 [0.0-0.2] μSv among sonographers and 3.6 [1.4-6.5] μSv among interventional cardiologists, representing an 18-fold greater radiation dose to interventional cardiologists (p<0.001). During 30 consecutive PMVCPs, the median effective dose per case was 0.0 [0.0-0.2] μSv among sonographers and 0.9 [0.1-12.2] μSv among interventional cardiologists, representing a significantly greater radiation dose to interventional cardiologists (p = 0.02). The effective radiation doses among sonographers and interventional cardiologists are shown in the Figure. **Conclusion:** The present findings indicate that radiation doses received by sonographers during TEEFPs are generally low and significantly less than the radiation doses received by interventional cardiologists. While the low radiation doses observed among sonographers are encouraging with respect to radiation safety, continued vigilance to chronic radiation exposure is needed as sonographers become increasingly involved with these procedures.



P2-87

Comparison of 3-Dimensional and 2-Dimensional Transseptal Puncture Height Measurement: A Pilot Study

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Background: Transcatheter procedures involving access to the left atrium require a transseptal (TS) puncture. Puncture height over the mitral valve annulus is typically measured with 2-dimensional (2D) transesophageal echocardiography (TEE) but 3-dimensional (3D) measurements have not yet been validated. **Methods:** Procedural TEEs for MitraClip mitral valve repair at St. Michael's Hospital (Toronto, Canada) from January 1, 2017 to December 31, 2017 were reviewed. During the procedure, 2D height was measured first and used for decision making regarding the puncture. Following this, a 3D dataset was obtained and height was measured on a crop plane that intersected the TS needle and mitral annulus at a point perpendicular to the mitral annular plane. This was generated with two sequential "2 click" crops on the General Electric Vivid E95 system with a 6VT-D TEE probe. The difference between paired measurements was assessed using a sign test. **Results:** 12 studies with both 2D and 3D TS height measurements were analyzed. Average deviation of the 3D measurement compared to the 2D was 1.7 +/- 1.1 mm (p = 0.012). Mean and median TS height measurements in 2D were 40.5 +/- 3.7 mm and 41 mm, respectively; in 3D were 42 +/- 4 mm and 42 mm, respectively. **Conclusions:** 3D TS height measurements were statistically significantly longer compared to 2D measurements in this pilot study where an appropriate 3D crop plane was generated. However, the absolute difference in measurement is small and not likely clinically relevant for procedural decision making. Use of 3D measurements may be a useful alternative when accurate 2D measurements are not possible, or are in doubt and require verification. Further studies are needed to evaluate if 3D measurements are more accurate than 2D in the setting of challenging anatomy, such as with a small left atrium, large aortic root, or abnormalities in the interatrial septum, especially if a standardized method is used to maximize 3D measurement accuracy.

P2-88

Using Left Atrial Strain to Diagnose Heart Failure with Preserved Ejection Fraction

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Background: Left atrial (LA) function as measured by LA strain is impaired in heart failure with preserved ejection fraction (HFpEF). We sought to evaluate whether using LA strain improved echocardiographic diagnosis of invasively confirmed HFpEF. **Methods:** Consecutive patients who had image quality suitable for measuring LA strain at rest, underwent gold standard invasive cardiopulmonary exercise testing to diagnose HFpEF (rest pulmonary capillary wedge pressure (PCWP)≥15mmHg and/or exercise≥25mmHg). Atrial reservoir strain was measured in all patients, with conduit and booster strain measured only in patients in sinus rhythm. **Results:** A total of 363 out of 431 patients had measurable LA strain (HFpEF-238, control-125). LA reservoir strain was impaired in HFpEF compared to controls (29 ± 16 vs 40 ± 13%,p<0.0001) as was conduit strain (18 ± 10 vs 22 ± 10%,p=0.0001). LA reservoir strain was the single most predictive echocardiographic measure of HFpEF (AUC 0.719, p<0.0001) with superior performance to E/e' (AUC difference +0.117, p<0.0001), left atrial enlargement (AUC difference +0.090, p=0.001), tricuspid regurgitation velocity>2.8 m/s (AUC difference +0.082, p=0.0085), LV hypertrophy (+0.0159, p<0.0001) and global longitudinal LV strain (AUC difference +0.0198, p<0.0001). Indexing LA reservoir strain to estimated LA pressure (E/e') as a measure of LA compliance further improved diagnostic performance compared to using only LA reservoir strain, AUC 0.772, p<0.0001 [AUC difference +0.053, p=0.003]. **Conclusions:** LA reservoir strain provides the highest diagnostic accuracy of any single echocardiographic measure to diagnose HFpEF. Indexing LA reservoir strain to E/e' further improved diagnostic accuracy.

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P2-89

In Patients with Heart Failure, Left Atrial Volume Surpasses Serum Brain Natriuretic Peptide as a Predictor of Readmission

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Background: Increased levels of brain natriuretic peptide (BNP) and left atrial enlargement have been independently associated with higher readmission rates in patients with heart failure (HF). We compared readmission rates in HF patients stratified by BNP levels and LA volume (LAV). **Methods:** This was a retrospective, single center study of 531 patients admitted with HF, 50% of whom had heart failure with reduced ejection fraction, over a 24-month interval. Patients with isolated pre-capillary pulmonary hypertension, heart transplant, left ventricular assist device, and end-stage renal disease were excluded. LAV was obtained by routine transthoracic echocardiography during index admission. Patients were stratified according to LAV, using LAV <60 mL; LAV 60-90 mL; and LAV > 90 mL. Patients were also grouped by pre-discharge serum BNP, using levels of < 200 pg/mL; 200-400 pg/mL; >400 pg/mL. HF readmission was assessed at 1-, 6-, and 12-month intervals. **Results:** LAV >90 mL increased risk of readmission at 1 month (HR 13.8, 95% CI 5.3-35.9; p<0.001), 6 months (HR 38.7, 95% CI 17.5-85.4; p<0.001) and 12 months (HR 25.6, 95% CI 13.1-50.0; p<0.001). An LAV of 60-90 mL also significantly increased risk of readmission at 6 months (HR 4.1, 95% CI 1.9-8.9; p < 0.001) and 12 months (HR 3.4, CI 1.8-6.4; p < 0.001), but not at 1 month. BNP of > 400, but not 200-400, significantly increased risk of readmission at 1 month (HR 6.9, CI 1.6-28.8; p = 0.009), 6 months (HR 3.0, CI 1.5-6.1; p = 0.002), and 12 months (HR 2.9, CI 1.5-5.6; p=0.001). However, when adjusted for age, gender, hypertension, body mass index, coronary artery disease, hypertension, atrial fibrillation, glomerular filtration rate, left ventricular function, right ventricular function, and mitral regurgitation, elevated BNP was no longer associated with HF readmission, while increased LAV remained a strong predictor of HF readmission: LAV of 60-90 mL increased risk of 6-month (HR 4.2, 95% CI 1.9-9.5; p=0.005) and 12-month (HR 3.4, 95% CI 1.8-6.7; p<0.001), but not 1-month readmission (HR 2.1, 95% CI 0.76-6.1; p=0.15). Furthermore, LAV >90 mL significantly increased risk of 1-month (HR 13.3, 95% CI 4.9-36.3; p<0.001), 6-month (HR 42.9, 95% CI 18.5-99.5; p<0.001), and 12-month readmission (HR 26.7, 95% CI 13.1-54.4; p<0.001). **Conclusions:** In this cohort of HF patients, after adjustment for relevant clinical and echocardiographic parameters, LAV was independently associated with increased HF readmission rates at 1, 6, and 12 months. When accounting for the same parameters, including LAV, pre-discharge serum BNP was no longer predictive of HF readmission.

P2-90

Prognostic Value of Septal Flash for Reduction of Left Ventricular Systolic Function on Isolated Left Bundle-Branch Block with Preserved Ejection Fraction Using Two-Dimensional Speckle-Tracking Echocardiography

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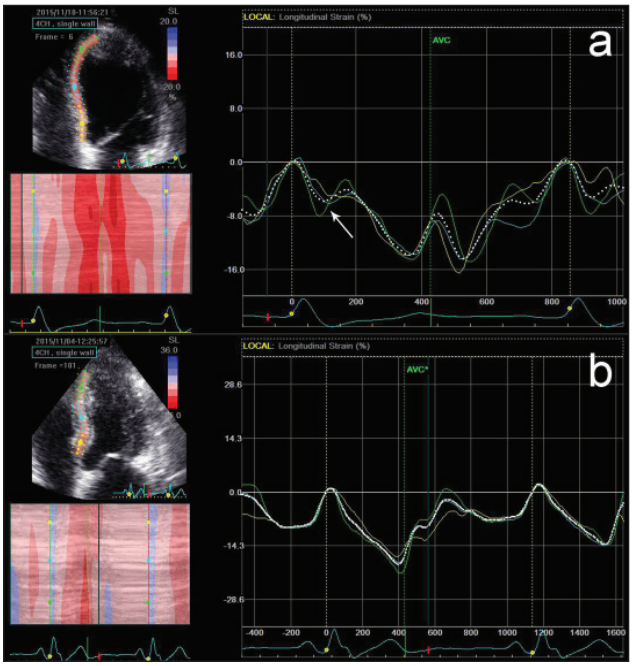
Background: Isolated complete left bundle branch block (cLBBB) patients may have different prognoses. It is significantly important to evaluate isolated cLBBB patients who are at risk for developing heart failure by early detection of left ventricular (LV) systolic function. The septal leftward motion, which is followed by a counter motion during early systole, is known as septal flash (SF) in cLBBB patients. This study aimed to determine the prognostic value of SF for reduction of LV global systolic function using two-dimensional speckle-tracking echocardiography (2D STE) in isolated cLBBB patients with preserved LV ejection fraction. **Methods:** Forty-one isolated cLBBB patients with preserved LV ejection fraction were studied and followed for 2 years. LV global longitudinal strain (GLS) using 2D STE was measured to assess LV global systolic function. The presence of SF was defined using 2D STE (Fig 1). **Results:** Multivariate logistic regression analysis identified the presence of SF as an independent factor predicting LV GLS > −20% in isolated cLBBB patients (odds ratio, 1.37; 95% confidence interval, 1.10-1.71; $p = 0.005$). Accordingly, cLBBB patients with SF had significantly lower LV GLS than patients without SF and controls (−17.31 ± 1.95, −19.89 ± 2.42 and −21.82 ± 1.23, $p < 0.001$). LV GLS in cLBBB patients with SF further decreased over time, whereas LV GLS did not decrease in patients without SF. The presence of SF was shown to be an independent factor predicting the reduction of LV global systolic function (a relative reduction in LV GLS >15% from baseline to 2-year follow-up) (odds ratio, 1.30; 95% confidence interval, 1.04-1.63; $p = 0.02$). **Conclusions:** SF was shown to be independently associated with decreased LV GLS in isolated cLBBB patients with preserved LV ejection fraction. Isolated cLBBB patients with SF should receive special attention and undergo regular follow-up. The assessment of SF by 2D STE may be an easy and effective way to predict reduction of LV global systolic function in isolated cLBBB patients. This is a preliminary study and some larger and longer prospective studies are necessary to verify these results.



P2-91

Thromboembolic Risk Post Cardioversion in Patients with Atrial Fibrillation and Left Atrial Appendage Sludge on Transesophageal Echocardiogram

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Background: In patients with Atrial fibrillation (AF) who are planned for sinus rhythm restoration by direct current (DC) cardioversion or pulmonary vein isolation (PVI), studies have shown increased risk of thromboembolic (TE) events with presence of thrombus in left atrial appendage (LAA), hence, to be considered as a contraindication. Although, finding LAA sludge increases the long-term risk of TE events, short-term risk of TE events post cardioversion is still undefined. **Methods:** This is a retrospective study of a total of 240 patients with AF who underwent transesophageal echocardiography (TEE) to rule out LAA thrombus prior to DC cardioversion or PVI. LAA sludge was defined as a dynamic, layered echodensity without a discrete mass, visualized throughout the cardiac cycle. Primary outcomes, include TE events and all-cause mortality, were assessed for 30 days post cardioversion. Patients with valvular AF (including mitral valve replacement or repair, moderate to severe mitral stenosis) were excluded. By two independent TEE readers, patients with confirmed LAA sludge (n = 133 [55%]) were included in the analysis. Patients with AF without evidence of spontaneous echocardiographic contrast or thrombus were included as controls (n = 107 [45%]). **Results:** In 133 patients with confirmed LAA sludge on TEE, 61 patients underwent DC cardioversion. In the remaining 72 patients, cardioversion was cancelled by the managing physicians. Cardioversion was successful in restoring sinus rhythm in 54 patients (89%), however, 16 patients (31%) had recurrence of AF at 8-week follow up. Compared to the control group, patients with sludge showed significantly higher CHADSs-VASc score (4.6±2.1 vs. 2.3± 1.7). They also showed significant LA enlargement (65% vs. 16%), reduced LAA emptying velocity (18±6 vs. 44± 18 cm/s), LV reduced ejection fraction (38 ± 15 vs. 50 ± 12). Within 30 days post cardioversion, no TE events were detected in both sludge and control groups, while 30 days all-cause mortality rate was 5% compared to 2% respectively. **Conclusion:** With half of the LAA sludge patients have received cardioversion, we found lack of consensus in practice in considering LAA sludge as a risk factor for TE to prevent cardioversion. Despite no difference in TE event rate detected, further studies are required to confirm these findings.

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Table. Comparison of baseline characteristics and echocardiographic parameters in patients with sludge and control groups.

	Sludge (N=133)	Control (N=107)	P value
Age, y	70 ± 12	63 ± 12	0.68
Male, n (%)	92 (69)	76 (71)	0.76
DCCA/PAVI, n (%)	61 (46)	103 (96)	< 0.001
Previous embolic events, TIA, or ischemic stroke, n (%)	25 (19)	11 (10)	0.07
Hypertension, n (%)	103 (79)	56 (53)	< 0.001
Congestive heart failure, n (%)	84 (64)	24 (23)	< 0.001
Diabetes mellitus, n (%)	50 (38)	17 (16)	< 0.001
CHADS2-VASc score	4.6 ± 2.1	2.3 ± 1.7	< 0.001
Pre-TEE anticoagulation, n (%)	127 (98)	94 (88)	< 0.001
Heparin, n (%)	50 (41)	42 (39)	0.83
NOAC, n (%)	37 (28)	1 (1)	< 0.001
Aspirin, n (%)	64 (50)	29 (27)	< 0.001
INR at TEE	1.81 ± 0.73	1.77 ± 1.04	0.26
INR at follow-up	2.43 ± 0.80	2.17 ± 0.65	0.33
Moderate or severe LA enlargement, n (%)	87 (65)	14 (16)	< 0.001
LVEF, %	38 ± 15	50 ± 12	< 0.001
LAA emptying velocity, cm/s	18 ± 6	44 ± 18	< 0.001
RV dysfunction, n (%)	86 (68)	26 (24)	< 0.001
LV hypertrophy, n (%)	23 (23)	61 (57)	< 0.001
Aortic stenosis, n (%)	5 (5)	5 (5)	NS
Aortic regurgitation, n (%)	40 (33)	15 (15)	0.002
Mitral regurgitation, n (%)	107 (84)	75 (70)	0.014
Tricuspid regurgitation, n (%)	99 (80)	106 (100)	< 0.001
AF or AFL at TEE, n (%)	121 (91)	92 (86)	0.223

P2-92

Left Atrial Strain and Left Atrial Mechanical Function Predict Recurrence of Atrial Arrhythmia After Catheter Ablation for Atrial Fibrillation

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Background: Abnormal left atrial (LA) structure and function are known to increase the risk of recurrent atrial arrhythmia (AA) after catheter ablation (CA), specific measures of LA function associated with recurrence are very important. We hypothesized that reduced LA strain and LA mechanical function may help predict recurrence of AA after catheter ablation for atrial fibrillation (AF). **Methods:** Patients who underwent CA for the first time for AF between April 2009 and May 2011 were included. Transthoracic echocardiogram was performed at baseline (pre-CA), 24 hours and 3 months post-CA. Peak negative longitudinal strain during LA contraction in late diastole (LAa strain) was measured at the inferior wall in patients with sinus rhythm (87, 144 and 140 patients at baseline, 24 hours and 3 months post-CA, respectively). LA mechanical function included LA volume index, LA emptying fraction, mitral inflow pulsed wave Doppler (E and A velocity) and pulmonary vein pulsed wave Doppler (S, D and A velocities). Recurrence of AA (included AF, Atrial Flutter and Atrial Tachycardia) was documented by electrocardiogram or Holter monitoring. The primary outcome was recurrence of AA occur after 3 months post-CA. Cox proportional hazard model was used to investigate the relationship between LA function and recurrence of AA. **Results:** A total of 157 patients (76% men, age 61±10 years) with more than 3 months post-CA follow-up were identified (mean follow-up 36±33 months). Of these, 78 patients had confirmed recurrence of AA (median time to recurrence 25 months). LAa strain at baseline, 24 hours and 3 months post-CA were -17%, -10.9% and -15.4% in recurrent group (p<0.0001) and -17.7%, -13.4% and -16.5% in nonrecurrent group (p<0.0001). A greater reduction (less negative) in LAa strain at 24 hours after CA was associated with recurrent AA (mean -10.9% vs. -13.4%; HR=1.11, p=0.002). Recurrence of AA was also associated with higher baseline peak early diastolic (E) mitral inflow velocity (mean velocities 0.79 m/s vs. 0.72 m/s; HR=3.58, p=0.03), higher baseline peak diastolic (D) pulmonary vein flow (mean velocities 0.55 m/s vs. 0.48 m/s; HR=5.36, p=0.03), higher 24 hour post-CA peak diastolic (D) pulmonary vein flow (mean velocities 0.66 m/s vs. 0.56 m/s; HR=5.82, p=0.008) and lower 3-months LA emptying fraction (mean 35% vs. 40%; HR=0.96, p=0.0009). **Conclusions:** Reduced LAa strain and worse diastolic dysfunction at baseline and following CA may be useful in predicting AA recurrence. Inferior wall LAa strain measurement is quick and practical and could be helpful in risk stratification of patients after CA for AF.

P2-93

Pathophysiologic Mechanism of Acute Kidney Injury in Patients with Acute Atrial Fibrillation

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Background: Atrial fibrillation (AF) is characterized by a loss of atrial mechanical activity, which impairs ventricular filling, potentially increasing the risk of compromised end-organ perfusion. The pathophysiologic mechanism of acute kidney injury in patients with new-onset atrial fibrillation remains elusive. We hypothesize that patients with new-onset AF have impaired left ventricular filling and impaired renal function. **Methods:** A population-based case-control study was conducted in 503 patients from Olmsted County, MN with incident AF diagnosed between 1994-2010, matched with 503 controls with no history of AF by age and sex. Both the cases and controls had normal creatinine levels prior to AF diagnosis (index date). Both groups had Echocardiogram at baseline and after the index date. We analyzed the associations of acute kidney injury and echocardiographic measures of ventricular filling and cardiac output with new-onset AF. **Results:** The mean age of the study population was 75.9±11.0 years. The overall baseline serum creatinine (ScR) was 0.9±0.16 mg/dl. Prior to the index date, the cases had an elevated E/e' ratio (15.7±9.0 vs 13.1±6.1, P=.001) and lower ejection fraction (LVEF) (58.0±12.9 vs 60.4±9.7, P=.001) compared to the controls. The prevalence of acute kidney injury was higher among AF cases (23.8 % v 8.9 %, P<0.001) than non-AF controls after the index date. Patients with incident AF had lower cardiac index (2.9±0.7 vs 3.1±0.7 L/min/m^2, P=.003) compared with controls. ScR increased by 20% in AF cases compared to 8% in controls, P<.001. Cardiac index decreased by 20% in AF cases vs 2% in controls, P=.01. On using multivariable logistic regression analysis, after adjusting for age, BMI, HTN, CHF, use of beta blockers, Ca^{+2} channel blockers, diuretics and other potential confounders, clinical variables associated with acute kidney injury were reduced LVEF, OR 1.03, 95% CI (1.01-1.07) and elevated E/e' ratio, OR 1.03, 95% CI (0.99-1.07). **Conclusions:** New-onset AF is associated with a meaningful reduction in renal function, which can be attributed to the decrease in cardiac output due to the impaired left ventricular filling.

P2-94

Effect of Mitral Regurgitation on the Prevalence of Left Atrial Appendage Thrombus and Subsequent Stroke in Patients Undergoing Transesophageal-Guided Cardioversion for Non-valvular Atrial Fibrillation

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Background: Although prior research in patients with rheumatic heart disease and atrial fibrillation (AF) has shown a reverse relationship between the severity of mitral regurgitation (MR) and the prevalence of left atrial appendage thrombus (LAAT), the impact of MR on thromboembolic risk in patients with non-valvular AF (NVAF) is unknown. The objective of this study was to investigate the effect of MR severity on the prevalence of LAAT and subsequent stroke in patients undergoing transesophageal (TEE)-guided electrical cardioversion (ECV) for NVAF. **Methods:** 3214 AF patients who underwent TEE-guided ECV from January 2011 to January 2015 were retrospectively analyzed to determine the relationship between MR severity and the prevalence of left atrial appendage thrombus (LAAT) and subsequent stroke. MR severity was assessed by Doppler echocardiography and classified as mild, moderate or severe. Multivariable regression models were used to identify independent predictors of LAA thrombus (logistic) and ischemic stroke (Cox). **Results:** Among the 3214 patients studied, 2376 (73.9%) had mild MR, 680 (21.2%) had moderate MR and 158 (4.9%) had severe MR. The overall prevalence of LAAT was 1.43%. Anticoagulation status did not differ among the groups; the mean INR's were 1.92±0.88, 1.87±0.86, and 1.81±0.90, respectively (p=.29). CHA_2DS_2-Vasc scores and the prevalence of heart failure were increasingly higher with greater severity of MR (3.02±1.6, 3.53±1.5, 3.78±1.5, respectively; p<.001) and (39.7%, 48.5%, 69%, respectively; p<.001). Conversely, LVEF and LAAEV were progressively lower with greater severity of MR (52.3±13.3, 49.3±14.5, 44.9±17.5, respectively; p<.001 and 38.0±21.2, 32.2±18.0, 26. 9±14.3, respectively; p<.001). There was a non-statistically significant trend toward a higher prevalence of LAAT in patients with greater severity of MR (1.2%, 1.9%, 3.2% p=.06). Stepwise multivariable regression analysis showed no association of MR (moderate or severe) with LAAT (OR 1.01, 95% CI 0.47-2.14 and OR 1.24, 95% CI 0.40-3.87, respectively). Independent predictors of LAAT were hypertension, reduced LVEF, and reduced LAAEV. After a mean follow-up of 3.4±2 years, adjusted Cox regression analysis showed no association of MR (moderate or severe) with ischemic stroke. Independent predictors of stroke were CHA_2DS_2-VASc score, LAAT, and reduced LAAEV. **Conclusion:** Severity of MR was not associated with increased incidence of LAAT. Hypertension reduced LVEF and reduced LAAEV were independent predictors of LAAT.

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Prognostic Significance of Patent Foramen Ovale in Patients Undergoing Transesophageal Echocardiography-Guided Electrical Cardioversion for Atrial Fibrillation

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Background: Previous studies have postulated a causal role for patent foramen ovale (PFO) in the etiology of embolic stroke. Although atrial fibrillation (AF) is known to be associated with increased risk of stroke compared with patients without AF, outcome differences between patients with AF and PFO are unknown. This study aimed to measure the differences, if any, in AF recurrence and ischemic stroke between patients with PFO compared with those without. **Methods:** We analyzed prospectively collected data on 3,329 patients undergoing their first successful transesophageal echocardiography (TEE)-guided electrical cardioversion (ECV) for persistent AF between May 2000 and March 2012. PFO with shunting at the atrial level was identified by color Doppler and agitated saline contrast study. Patients were excluded if they had a history of congenital heart disease, ≥moderate mitral regurgitation or stenosis, valve surgery or no documented assessment of interatrial shunting (n=1078). All patients were followed up after ECV for first documentation of recurrent AF, or ischemic stroke. Cox regression models were used to compare AF recurrence and cerebrovascular events between groups. **Results:** The mean age was 68.3±12.4 years and 69.5% were men. Of 2251 patients studied, 400 (18.6%) had PFO. Patients with PFO had higher mean peak left atrial appendage velocity (LAAEV) (40.1±22.4 vs 37.9±21.2 cm/s, *P*=.04), and a non-significant increase in the frequency of obstructive sleep apnea (OSA) (22.2% vs 17.7%, *P*=.06) Otherwise, baseline characteristics including age, sex, body mass index, CHA_2DS_2-VASc score, duration of AF, left atrial (LA) size, and left ventricular ejection fraction were similar between the 2 groups (p=NS). During the follow-up period (6.4±4.3 years), 1631 (72.5%) patients developed AF recurrence, and 164 (7.3%) had ischemic stroke. Multivariable Cox regression analysis, adjusting for CHA_2DS_2-VASc score, OSA, LA size, LAAEV, and warfarin at discharge, revealed no significant association between PFO and AF recurrence, HR 1.03, 95% CI (0.89-1.20), or ischemic stroke HR 0.73 95% CI (0.43-1.22). Independent predictors of stroke were CHA_2DS_2-VASc score HR 1.31, 95% CI (1.16-1.48) and LAAEV, HR 1.07, 95% CI (1.02-1.13). LAAEV was the only significant predictor of AF recurrence HR 1.06, 95% CI (1.03-1.09). **Conclusion:** The presence of PFO was not independently associated with increased risk of ischemic stroke or AF recurrence following cardioversion for NVAF. More studies are needed to further examine the impact of directionality of interatrial flow on clinical outcomes in this patient population.

P2-96

Differences in Atrial Strain Relative to Atrial Size in Athletes Attending the National Basketball Association Draft Combine

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Background: Atrial dilatation is common amongst elite athletes but is of unclear clinical significance. Deformational analysis utilizing speckle-tracking echocardiography (STE) has emerged as a novel technique to assess atrial mechanics and function. We hypothesized that atrial dilation is associated with alterations in atrial strain parameters. **Methods:** From 2010-2016, male athletes at the National Basketball Association Draft Combine underwent comprehensive echocardiography, and STE was utilized to measure left atrial (LA) strain in 183 individuals and right atrial (RA) strain in 40 individuals with GE Health Care's EchoPac Software. The P-wave was used as the reference point on the EKG to calculate atrial booster, conduit, and reservoir STE-derived strain. Left atrial volume index (LAVI) of < 34 ml/m^2 was considered normal versus ≥ 34 ml/m^2 enlarged, whereas a right atrial volume index (RAVI) of ≥ 39 ml/m^2 (two standard deviations above the mean) was used as the cut-off for the RA. Independent samples t-tests were used to assess for differences in strain relative to atrial size and compare LA and RA strain. Strain is reported as a mean with one standard deviation. **Results:** LAVI was normal in 102 (56%) and dilated in 81 (44%) individuals, whereas RAVI was normal in 25 (63%) and dilated in 15 (37%) of individuals. Mean LA conduit and reservoir strain were significantly reduced in those with LA dilation compared to those without. No significant difference was seen in mean LA booster strain or any measure of mean RA strain relative to atrial size (see Table 1). All measures of mean LA strain were higher than mean RA strain (see Table 2). **Conclusions:** In our cohort of elite basketball players, LA dilation was associated with decreased mean LA reservoir and conduit strain. RA dilation did not result in differences in the mean RA strain. Mean LA strain was significantly higher than mean RA strain. Prospective follow-up is needed to elucidate any clinical consequences of these differences in deformation.

Chamber and Strain	Mean Strain LAVI < 34 ml/m2 (SD)	Mean Strain LAVI ≥ 34 ml/m2 (SD)	Mean Strain RAVI < 39 ml/m2 (SD)	Mean Strain RAVI ≥ 39 ml/m2 (SD)	Net Difference	p-value
LA Booster	9.6 (2.9)	9.7 (2.2)			0.1	0.920
LA Conduit	28.2 (7.1)	24.5 (5.2)			3.7	0.020
LA Reservoir	35.7 (9.7)	32.7 (7.3)			3.0	< 0.001
RA Booster			5.0 (2.8)	5.4 (1.8)	0.4	0.614
RA Conduit			11.2 (5.6)	9.9 (5.5)	1.3	0.463
RA Reservoir			16.2 (6.7)	15.3 (5.4)	0.9	0.650

Pair	Chamber and Strain	Mean (SD)	Net Difference	p-value
1	LA Booster	9.1 (3.0)	3.9	< 0.001
	RA Booster	5.2 (2.5)		
2	LA Conduit	26.8 (7.6)	16.1	< 0.001
	RA Conduit	10.7 (5.5)		
3	LA Reservoir	35.9 (8.6)	20.0	< 0.001
	RA Reservoir	15.9 (6.2)		

P2-97

Relationship Between Electrocardiographic Characteristics and Left Ventricular Systolic Dysfunction in Isolated Left Bundle Branch-block Patientswith Preserved Ejection Fraction

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Background: Isolated complete left bundle branch block (cLBBB) individuals, without any evidence of heart disease, also may have diminish cardiac performance. Clinicians urgently need to find an easy way to detect left ventricular (LV) systolic dysfunction of cLBBB. Electrocardiogram (ECG) is a common and effective method for clinical diagnosis of cLBBB, but the relationship between ECG characteristics and LV systolic dysfunction in isolated cLBBB patients is unclear. Our aim is to evaluate the relationship between specific ECG characteristics and LV systolic dysfunction in isolated cLBBB patients using two-dimensional speckle-tracking echocardiography (2D STE). **Methods:** Fifty isolated cLBBB patients with preserved LV ejection fraction were selected using standard 12-lead ECG. Concordant or discordant T wave of cLBBB was defined as a positive or negative T wave in leads V5, V6 or D1. Residual conduction of cLBBB were defined as an r wave in V1≧1 mm and/or a q wave in aVL≧1 mm. LV global longitudinal strain was measured using 2D STE to assess LV global systolic function. LV longitudinal systolic dysfunction was defined as LV global longitudinal strain > −20%. **Results:** There were 29 cLBBB patients with LV longitudinal systolic dysfunction, and they have longer QRS duration (158 ± 11 vs. 149 ± 11, p = 0.006), higher presence of discordant T wave (62.1% vs. 28.6%, p = 0.03), lower presence of residual conduction in cLBBB (31.0% vs. 61.9%, p = 0.04) (Table 1). The QRS duration (*OR*=1.08, 95% *CI*: 1.01~1.16, *p*=0.02), discordant T wave (*OR*=1.42, 95% *CI*: 1.03~16.72, *p*=0.04) and the absence of residual conduction (*OR*=1.37, 95% *CI*: 1.01~15.52, *p*=0.04) were independent factors for predicting GLS > −20% in isolated cLBBB patients. The QRS duration of 153 ms was found to be the cut-off value to identify reduced LV longitudinal systolic function with the sensitivity and specificity of 72.4% and 76.2%. Discordant T wave and the absence of residual conduction in cLBBB predicts reduced LV longitudinal systolic function with the sensitivity and specificity of 62.1% and 71.4%, 72.4% and 57.1%, respectively. **Conclusion:** LV longitudinal systolic function decreased in some of isolated cLBBB patients with preserved LV ejection fraction. QRS duration, discordant T wave, the absence of residual conduction of cLBBB shown to be independently associated with decreased LV longitudinal systolic function. ECG characteristics might be an easy and effective predictor for the deterioration of LV systolic function.

P2-98

Right Atrial Function Changes in Tetralogy of Fallot

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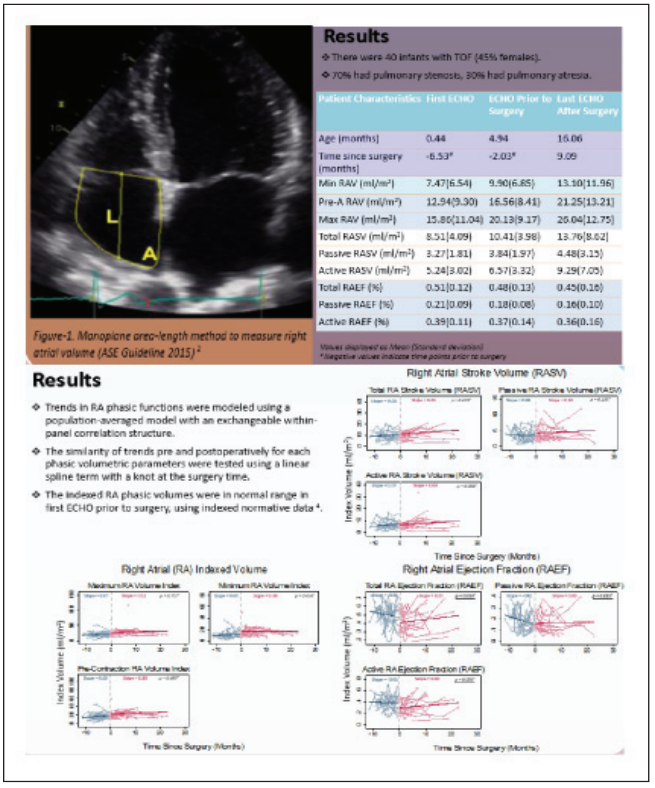
Background: There is limited information on right atrial (RA) function in the congenital heart defects. RA volume and function may give insight into the right ventricle (RV) diastolic function. We sought to assess RA function in tetralogy of Fallot (TOF) patients prior to and after complete surgical repair. **Methods:** Infants with TOF prior to complete repair were included for retrospective chart review and offline analysis of 2-dimensional echocardiograms (echo) before and after surgical repair. Patients were excluded if they had a significant arrhythmias, ≥ mild tricuspid regurgitation or stenosis, > a small atrial septal defect, sub-optimal echo images for RA measurements. RA phasic volumes and stroke volumes were calculated. All volumes were indexed to body surface area. **Results:** There were 40 infants with TOF (45% females), of which 70% had pulmonary stenosis, 30% pulmonary atresia. Roughly 85% and 60% had 3, or more, echo available pre- and postoperatively. Table 1 (attached) shows the patient characteristics and phasic RA

volumes. The indexed RA phasic volumes were in normal range in initial echo prior to surgery. We used normal index RA phasic volumes published by European Society of Echocardiography. There was increasing trend of indexed RA phasic volume on follow up echo immediately before TOF repair. These phasic volumes continued to remain elevated after complete surgical repair (Table 1). Trends in RA stroke volumes for all available echos before and after surgery were modeled using a population-averaged model with an exchangeable within-panel correlation structure (Figure 2), showing no statistical significant difference after surgery. But there was statistical significance noted in RA ejection fraction. Please see attached image for statistical analysis and results of the study. **Conclusion:** The indexed RA phasic volumes in children with TOF are normal initially and increases before TOF repair and it continued to increased after TOF repair. The increase RA phasic volumes suggest RV diastolic dysfunction similar to the findings of LA phasic volumes and left ventricular diastolic dysfunction. Our findings indicate slow worsening RV diastolic function in patients with TOF after surgical repair. RA volume and function can be novel marker to diagnose and monitor right ventricular diastolic dysfunction.



P2-99

Association of Left Atrial Function by Echocardiography in Patients Following Catheter Ablation of Atrial Fibrillation: Comparing Functional Indices and Strain to Predict Clinical Outcomes

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Background: Atrial fibrillation (AF) ablation is successful without recurrence in over 70% of patients after a year. Measuring the impact of ablation on LA function may provide insight into the mechanistic underpinning of recurrence and provide a means of documenting recovery. Our objective was to quantify LA strain (LAS), LA function index (LAFI), and diastolic function as more advanced methods of measuring LA function change cause by AF ablation, and to better predict which patients may remain in normal sinus rhythm following their ablation. **Methods:** In a prospective study, 50 patients with symptomatic paroxysmal (18) or persistent AF (32), scheduled for first-time AF ablation, underwent echocardiographic measures of the LA before ablation and immediately post ablation (within 48 hours). The Toshiba America Medical echocardiographic system was used to measure 2-D and 3-D LA parameters, including LAS, LA ejection fraction (LAEF), LA volumes, mitral inflow Doppler (E and A velocity, deceleration time), and Left ventricular outflow tract velocity time integral (LVOT VTI). 2-D LA function index (LAFI) was calculated as ((LAEF x LVOTVTI)/LA end systolic volume index). 48 patients had clinical outcomes, followed for a mean of 10.1 ± 4 months. There were 15 patients who had follow up echocardiograms with the same LA function parameters. **Results:** Of the 48 patients followed clinically, 39 (72.9%) were in normal sinus rhythm at their latest follow up (mean 10.1 ± 4 months) and 13 (27.1%) had a repeat ablation (mean 8.8 ± 4 months). Persistent AF at baseline was more likely (81.5% vs 12.5%, p=0.002) to result in recurrence of AF. Of the LA function parameters, lower LA emptying fraction, as calculated in LAFI was associated with increased AF recurrence (0.40 vs 0.49; p=0.039). Lower LAFI pre-ablation was more strongly associated with increased AF recurrence (0.1958 vs 0.3580; p=0.005). In the post-ablation study, lower LAFI was associated with increased AF recurrence (0.2271 vs 0.3119; p=0.054). Shorter deceleration time was associated with increased AF recurrence (169 vs 199; p=0.049). **Conclusion:** Preablation LAFI was the strongest predictor of recurrence of AF and was more predictive than persistent versus paroxysmal AF at baseline. LAS was not predictive of recurrence, but strain warrants reexamination when refinements such as 3D strain are available.

P2-100

Left Atrial Sphericity Index Characterizes Left Atrial Function

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Background: Left ventricular sphericity has been used as a descriptor of global left ventricular function and remodeling. There are few studies investigating left atrial (LA) sphericity in settings other than atrial fibrillation. We hypothesize that LA sphericity falls within a narrow range of values in healthy subjects and that increased LA sphericity is a measure of impaired LA function. **Methods:** Two-dimensional LA sphericity was measured in end-diastole and end-systole in 123 healthy subjects (mean age 44±15) and in 18 subjects with cryptogenic stroke (mean age 58±13). Measurements were performed using a GE Vivid E9 system with EchoPAC software. LA sphericity index (LASph) was calculated as (ESV or EDV)/[(LA diameter^3 x π)/6]. LASph was compared to age, sex, LA function index, LA emptying fraction, and exercise tolerance. **Results:** In healthy subjects, LASph was not associated with age, sex, or exercise tolerance. Systolic & diastolic LASph was significantly associated with LA function index (p=0.0001 for diastole, p=0.001 for systole) and LA emptying fraction (p=0.0456 for diastole, p=0.001 for systole). This correlation was stronger for systolic LASph than for diastolic LASph. Systolic LASph was significantly greater in patients with cryptogenic stroke compared to healthy patients, but there was no significant difference in LA emptying fraction or LA function index between these groups (Table 1). **Conclusion:** LA sphericity index is a measure of LA shape that may be a useful descriptor of LA function. Patients with a history of cryptogenic stroke have significantly greater LASph than healthy patients. This study establishes the normal range for LASph and suggests that abnormalities in LASph are found in association with patients with cryptogenic stroke. These changes may precede differences in other descriptors of LA function.

Table 1: Measures of LA function in patients with and without cryptogenic stroke

	Healthy patients (n=123)	Cryptogenic stroke (n=18)	p-value
Age (years)	44 ± 15	58 ± 13	**0.0003**
Male	65 (53%)	10 (56%)	0.05
LA Function Index	0.52 ± 0.15	0.46 ± 0.15	0.18[1]
LA Emptying Fraction (%)	61 ± 8	54 ± 10	0.18[1]
LASph End-Systole	0.25 ± 0.07	0.32 ± 0.07	**0.003**[1]
LASph End-Diastole	0.51 ± 0.13	0.52 ± 0.13	0.6[1]

[1]adjusted for age & gender

P2-101

Assessment of Global Myocardial Deformation in Fetal Tachyarrhythmias

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Background: Two-dimensional speckle-tracking echocardiography (2D-STE) is a newer diagnostic imaging modality that allows assessment of myocardial deformation. The published correlations of global and regional strain and strain rate data with advancing pregnancy are based on cross-sectional data (e.g., gestational age (GA) range 13-40 weeks). 2D-STE is an angle independent technique for assessment of myocardial deformation, which has allowed detection of preclinical myocardial dysfunction in children and adults. We sought to analyze if fetal left ventricular strain could be used as a tool to monitor effects of therapy and help determine timing of delivery in fetuses with sustained tachyarrhythmia. **Methods:** We retrospectively analyzed fetuses with tachyarrhythmia in the fetal cardiology clinic at Cleveland Clinic Foundation from 1/2000 to 1/2017. Fetuses with isolated ectopy and structural heart disease were excluded; Strain analysis was performed retrospectively using VVI Software; this was correlated with timing of tachyarrhythmia, initiation of therapy and disease progression in the fetus. Type of tachyarrhythmia, anti- arrhythmic therapy, GA, cardiovascular profile score and postnatal outcomes were recorded. **Results:** A total of 11 fetuses with tachyarrhythmias were identified with GA between 21 to 36 weeks at time of onset of arrhythmia. Arrhythmias identified included: AVRT (45%), atrial tachycardia (36%) and atrial flutter

(18%). Of 11 fetuses, 5 had anti arrhythmic therapy given to mothers while 4 converted spontaneously and 2 delivered at outside institutions. 2D STE measurements were found to be significantly reduced with the fetus in tachyarrhythmia (GLV 0.52+/-0.58cm/sec; strain -3.58+/- 4.97%; SR -0.67+/- 0.84/sec); and improved with return to sinus rhythm (GLV 1.29+/-1.29cm/sec, strain -8.86+/-8.5%; SR -1.35+/-1.42/sec) reaching statistical significance. **Conclusion:** Our study is the first to evaluate myocardial deformation in fetal tachy-arrhythmias. We note that 2D STE analysis is a useful adjunctive beneficial tool to assess myocardial function in fetal arrhythmia. Therapy and return to sinus rhythm appeared to result in improved deformation parameters. It will also aid in predicting the potential outcomes of the fetuses and timing of delivery.

Maternal and Fetal Parameters

No	GA at diag	Type of arrhythmia	FHR	Maternal therapy	CVS profile	Response to therapy	GA at delivery	Postnatal arrhythmias
1	25	AVRT	260	Digoxin +Flecainide	7	Yes	38	No
2	32.5	2:1Atrial flutter	250	Digoxin	10	Yes	38	No
3	30	AVRT	250	Digoxin	8	No	32	Yes AVRT
4	32	Atrial tachycardia	205	None	10		38	No
5	21	EAT	240	None	10		37	No
6	32	AVRT	260	Digoxin+flecainide	1	No	33	Yes AVRT
7	30	2:1 Atrial Flutter	215	None	4		33	Yes A flutter
8	31	AVRT	265	Dig+Sotol	1	Yes	35	Yes AVRT
9	28	EAT	225	None	10		38	No
10	36	AVRT	200	None	4		38	No
11	28	Atrial tach	200	None	10		38	No

2D-STE Measurements

Parameter	In tachycardia	In sinus rhythm	P values with therapy
Global longitudinal velocity (cm/sec)	0.52 ± 0.58	1.29 ± 1.29	0.003
Strain (%)	-3.58 ± 4.97	-8.86 ± 8.5	0.0006
Strain rate (1/sec)	-0.67 ± 0.84	-1.35 ± 1.42	0.001

P2-102

Relationship Between the Thrombus on Device and Selection of Anticoagulant Drugs after Left Arial Appendage Closure

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Background: Left atrial appendage closure (LAAC) is the latest interventional procedure for prevention of stroke in patients with atrial fibrillation. However, we found that some patients suffered from thrombus on the device during follow-up after two months of LAAC. Further observation showed that most of patients with thrombus were administered dabigatran after LAAC. The aim of this study was to clarify the relationship between the thrombosis and selection of the anticoagulant drugs after LAAC. **Methods:** Study population included 98 patients (62 males, mean age 68.3 ± 9.7 years) with atrial fibrillation who had been successfully implanted with LAAC devices in our hospital. Continuous anticoagulation was administered for 2 months after LAAC. Forty-eight patients were treated with warfarin (INR range 2-3), 39 patients treated with 110 mg dabigatran twice-daily, and 11 patients treated with 20 mg rivaroxaban once-daily. There was no significant difference in CHA2DS2-VASc scores and HAS-BLED scores before LAAC among these three groups. Two-dimensional and three-dimensional transesophageal echocardiography (TEE) underwent at the end of 2-month anticoagulation. **Results:** There were 7 patients (7%) with thrombus on the top of LAAC device detected by TEE after two-month anticoagulation. The thrombus looked like a pile of cow dung on the crown and firmly stuck to the crown. One patient (2%) with thrombus received warfarin and 6 patients (15%) with thrombus received dabigatran. None of patient with thrombus received rivaroxaban. The thrombosis was significantly related to the selection of anticoagulant drugs (p = 0.035) by one-way ANOVA analysis. Dabigatran group was associated with nearly 10- folds compared to other two groups in the prevalence of postoperative thrombosis (odds = 9.4, p = 0.037) by binary logistic regression analysis. However, the incidence of thrombosis was no significant correlation with gender, age, atrial fibrillation classification, CHA2DS2-VASc score, HAS-BLED score, preoperative BNP measurement, left atrial size, left ventricular ejection fraction, history of diabetes, hypertension, stroke, renal insufficiency (p> 0.05 in all). **Conclusion:** The selection of anticoagulant drugs is critical for patients with atrial fibrillation after LAAC. The prevalence of thrombosis in patients administered dabigatran 110mg was associated with nearly 10-folds than the patients with warfarin or rivaroxaban. It is likely to increase the dosage of dabigatran or choose other anticoagulant drugs to avoid device thrombosis after LAAC.

P2-103

Left Atrium Changes in Patients with Maintenance Hemodialysis: Assessment via Real-Time Three-Dimensional Echocardiography

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Purpose: Previous studies have shown that increased left atrium (LA) volume predicts mortality in patients undergoing maintenance hemodialysis (MHD). We used real-time three-dimensional echocardiography (RT-3DE) to evaluate the long-term and immediate changes of LA function in MHD patients. **Methods:** Echocardiography was performed on 112 consecutively enrolled individuals, including 37 controls and 75 MHD patients. Conventional echocardiographic parameters and RT-3DE parameters of left atrium were obtained. Among them, twenty-eight patients were analyzed before and immediately after one hemodialysis session. LA maximum, minimum and pre-atrial contraction volumes (LAV-max, LAV-min, LAV-preA) were measured and LA reservoir, conduit and booster pump function were assessed. **Results:** Compared to the control group, MHD patients had markedly enlarged LA volumes (LAV-max: 38.1±10.5ml/m^2 VS 26.9±7.8 ml/m^2, LAV-min:15.2±4.7ml/m^2 VS 9.9±3.0 ml/m^2, LAV-preA: 29.3±9.2ml/m^2 VS 16.8±5.1ml/m^2, all p<0.001). Additionally, LA reservoir and conduit function were repaired, while the booster pump function was enhanced: LA global ejection fraction (LAEF): 60.3±4.7% VS 63.1±5.2%; LA passive EF(LAPEF): 23.1±10.6% VS 37.0±8.4%; LA active EF(LAAEF) : 47.6±7.7% VS 40.8±7.5%, all p<0.01. After one session of hemodialysis, LA volumes were decreased significantly (LAV-max: from 35.8±9.8ml/m^2 to 32.0±10.4ml/m^2; LAV-min: from 14.3±4.5ml/m^2 to 12.0±4.8 ml/m^2; LAV-preA: from 27.6±8.0ml/m^2 to 24.5±9.0 ml/m^2, all p<0.05). The LA booster pump function (LAAEF) was enhanced and the conduit function (LAPEF) remained unchanged, hence LAEF was increased significantly (LAAEF: from 48.0±7.7% to 51.0±6.0%, p=0.045; LAPEF: from 22.6±10.8% to 23.9±11.0%, p=0.461; LAEF: from 60.4±5.2% to 63.0±4.9%, p=0.004). In the MHD cohort, LA volumes were positively correlated with the serum concentration of NT-proBNP (r=0.406 for LAV-max, r=0.420 for LAV-min and r=0.415 for LAV-preA, all p<0.05). **Conclusions:** MHD patients endure LA enlargement and functional impairments. After one session of HD, LA booster pump function was enhanced as a compensatory mechanism for volume reduction. RT-3DE may have potential in the LA evaluation in MHD patients.

P2-104

Stroke in Mitral Valve Prolapse: Risk Factors and Left Atrial Function in Cryptogenic Versus Non-Cryptogenic Ischemic Subtypes

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Background and Purpose: Mitral valve prolapse (MVP) has been associated with an increased risk of ischemic stroke. Older age, thicker mitral leaflets, and significant mitral regurgitation (MR) leading to atrial fibrillation have been traditionally considered risk factors for ischemic stroke in MVP. However, specific risk factors for MVP-stroke subtypes are not well defined. The aim of this study is to evaluate clinical and echocardiographic parameters, including left atrial (LA) function, in MVP with cryptogenic (C) versus non-cryptogenic (NC) stroke. **Methods:** MVPs (defined as leaflet displacement > 2 mm) were identified in consecutive echocardiograms obtained after a stroke from January 2013 to December 2016. Age/gender matched MVPs without stroke and healthy controls without MVP were also identified. We analyzed LA end-systolic/diastolic volume index, emptying fraction (LAEF), function index (LAFI), and global longitudinal strain (LA GLS) in all MVPs and controls. We also measured left ventricular (LV) volume indexes, mass index, EF, degree of MR and leaflet thickness. **Results:** We identified a total of 30 MVP with stroke (11 with C- and 19 with NC-stroke), 20 MVPs without a stroke and 16 controls. MVPs without stroke had lower BMI, less hypertension but more MR (≥ moderate in 45% versus 17%), more abnormal LA function (lower LAEF, LAFI) and larger LV volumes/mass (all p < 0.05) when compared to MVPs with NC-stroke. Leaflet thickness was overall mild (< 3 mm) and similar in the 2 groups. Within the MVP stroke group, NC-stroke had higher BMI, more hypertension and more atrial fibrillation compared to C-stroke. In the variables tested, patients with C-stroke did not differ from controls. **Conclusions:** MVP-related MR may be protective against stroke despite abnormal LA function. Risk of NC-stroke in MVP is related to common stroke risk factors rather than leaflet thickening. The etiology of C-stroke in MVP warrants further studies.

P2-105

Influence of EKG Gating on Atrial Strain and Variability of the Measure in Athletes Attending the National Basketball Association Draft Combine

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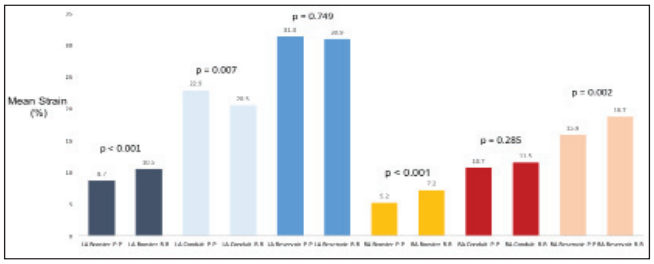
Background: Atrial strain has emerged as a novel parameter in the assessment of atrial function and remodeling. Controversy exists over the preferred method of EKG gating,

as well as the reliability of the measure between individuals and over time. **Methods:** From 2015-2016, male athletes at the National Basketball Association Draft Combine underwent comprehensive echocardiography, and speckle-tracking echocardiography (STE) was used to measure left atrial (LA) in 43 athletes and right atrial (RA) strain in 40 athletes with GE Health Care's EchoPac Software. Booster, conduit, and reservoir strain were measured using P-P and R-R EKG gating. Inter-observer and intra-observer variability was assessed on 40% of the sample (18 athletes) using LA strain gated P-P. Differences in mean strain and inter-observer and intra-observer variability was assessed using paired samples t-tests. Strain is reported as a mean with one standard deviation. **Results:** Mean LA booster strain was significantly higher with R-R gating relative to P-P gating, while mean LA conduit strain was higher with P-P gating relative to R-R gating. There was no difference in mean LA reservoir strain. Mean RA booster and reservoir strain were higher with R-R gating relative to P-P, with no difference in mean conduit strain (Figure 1, Table 1). There was a significant difference in mean LA conduit and reservoir but not booster strain amongst our two observers, with no difference in mean LA strain when measured by the same observer on two occasions (Table 2). **Conclusions:** Atrial strain differs based on EGK gating, with booster strain varying the most in our sample. We found significant inter-observer variability in LA strain, without significant intra-observer variability.



PAIR	STRAIN	GATING	MEAN (SD)	NET DIFFERENCE	P-VALUE
1	LA Booster	P-P	8.7 (2.1)	1.8	< 0.001
	LA Booster	R-R	10.5 (2.9)		
2	LA Conduit	P-P	22.9 (5.0)	2.5	0.007
	LA Conduit	R-R	20.5 (5.2)		
3	LA Reservoir	P-P	31.3 (6.0)	0.4	0.749
	LA Reservoir	R-R	30.9 (6.6)		
4	RA Booster	P-P	5.2 (2.5)	2.0	< 0.001
	RA Booster	R-R	7.2 (3.0)		
5	RA Conduit	P-P	10.7 (5.5)	0.8	0.285
	RA Conduit	R-R	11.5 (5.7)		
6	RA Reservoir	P-P	15.9 (6.2)	2.8	0.002
	RA Reservoir	R-R	18.7 (6.9)		

PAIR	PARTICIPANT	STRAIN	MEAN (SD)	NET DIFFERENCE	P-VALUE
1	First Observer	LA Booster	8.3 (1.4)	0.2	0.404
	Second Observer		8.0 (1.5)		
2	First Observer	LA Conduit	21.2 (3.8)	3.9	< 0.001
	Second Observer		17.3 (2.7)		
3	First Observer	LA Reservoir	29.4 (3.6)	4.1	< 0.001
	Second Observer		25.3 (3.1)		
4	Observer 1st Measure	LA Booster	8.0 (1.5)	0.2	0.928
	Observer 2nd Measure		8.0 (1.5)		
5	Observer 2nd Measure	LA Conduit	17.3 (2.7)	0.0	0.902
	Observer 2nd Measure		17.2 (2.7)		
6	Observer 2nd Measure	LA Reservoir	25.3 (3.1)	0.0	0.967
	Observer 2nd Measure		25.3 (2.9)		

P2-106

Is Transesophageal Echocardiographic Evaluation Prior to Cardioversion or Ablation Necessary in the Era of Non-vitamin K Antagonist Oral Anticoagulants?

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Background: Non-vitamin K antagonist oral anticoagulants (NOACs) have a rapid onset of action, fixed dosing, and limited drug and food interactions allowing patients to be therapeutically anticoagulated within minutes of taking the medication. In contrast, it is often difficult for patients on warfarin to maintain a therapeutic international normalized ratio (INR) because of warfarin's delayed onset of action and numerous drug and food interactions. Because of the favorable pharmacokinetic profile of NOACs, we hypothesized that, in comparison to patients with a subtherapeutic INR, those who missed one or more NOAC doses in the three weeks prior to cardioversion or ablation would have a lower incidence of left atrial appendage (LAA) thrombus on transesophageal echocardiography (TEE). **Methods:** We reviewed the electronic health records of all patients who had a TEE prior to cardioversion or ablation at Massachusetts General Hospital from November 14, 2016 to March 31, 2017. Patient demographics, medical history, medication history, TEE results, and 30-day event rates (transient ischemic attack (TIA), stroke (CVA), myocardial infarction (MI), and other ischemic events) were recorded. **Results:** A total of 216 TEEs were performed of which 93 (43%) were performed because of a suspected subtherapeutic INR or missed NOAC dose. 41 (44%) patients were anticoagulated with warfarin and 52 (56%) patients were anticoagulated with a NOAC. The majority (70%) of patients were male. The average age was 70 ± 9 with an average CHA_2DS_2-VASc score of 4. There was no significant difference in peak LAA emptying velocity between the warfarin group and NOAC group (warfarin: 36.0 cm/sec ± 16.6; NOAC: 37.2 cm/sec ± 13.1, p=.719). There was no significant difference between the two groups in the number of patients with spontaneous echo contrast (p=.147). None of the patients who reported missing one or more NOAC doses were found to have a LAA thrombus. Two (5%) patients who were anticoagulated with warfarin were found to have a LAA thrombus. Both patients with LAA thrombi had confirmed subtherapeutic INRs and a history of mitral valve replacement. No patients in either group had a TIA, CVA, MI, or other ischemic event at 30 days post-cardioversion or ablation. **Conclusion:** In this retrospective chart review, no patients who missed one or more NOAC doses in the three weeks prior to cardioversion or ablation were found to have a LAA thrombus. If this result is reproducible in a larger prospective study, it has the potential to change clinical practice, decrease unnecessary procedures, and reduce healthcare costs.

P2-107

Novel Oral Anti-Coagulant Therapy is Safe and Efficacious in the Treatment of Intra-Cardiac Thrombi

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Data regarding use of novel oral anticoagulants (NOACs) for the treatment of left atrial (LA), left atrial appendage (LAA), and left ventricle (LV) intra-cardiac thrombi is particularly scarce. Current guidelines recommend the use of the vitamin K antagonist (VKA) Warfarin. This retrospective analysis investigated the safety and efficacy of NOACs in the successful resolution of intra-cardiac thrombi. Seventy-three consecutive patients with intracardiac thrombus identified by Transesophageal echocardiogram were evaluated. Thrombus-related patient outcome data was then retrospectively collected, which included choice of anticoagulant (warfarin, dabigatran, rivaroxaban, edoxaban, apixaban), demographic data (age, gender), initial TEE findings, follow-up TEE outcomes, and incidence of adverse events such as, major bleeding, myocardial infarction (MI), cardiac hospitalization, stroke/transient ischemic attack (TIA), and death. Clinical and baseline data were analyzed at baseline, follow up TEE exam, and 6 months post initial exam. Of patients in our study, 43 (58.9%) had successful resolution of intra-cardiac thrombi on follow-up TEE. Nineteen (44.2%) of the 43 patients with resolution were treated with warfarin, while 24 (55.8%) were treated with a NOAC. Observed thrombus resolution rate overall was 50% for the VKA group and 68.5% for the NOAC group. 91.7% of those patients on 300mg Dabigatran, 57.1% of those on 10mg Apixaban, and 55.6% of those on 20mg of Rivaroxaban had successful resolution of thrombi. Of patients with resolved thrombi, ten (23%) were female. Mean age in the VKA group was 71 and 69 in the NOAC group. Mean follow-up TEE time interval was 85.3 days for the VKA group and 104 days for the NOAC group. There was one (5%) incident of cardiac hospitalization in the VKA group, and three (12.5%) incidents of cardiac hospitalization in the NOAC group - one with each NOAC type. No other adverse events were documented on chart review at 6 months. Our analysis suggests that NOAC therapy may equal, or even surpass, guideline recommended warfarin therapy in regards to safety and efficacy of intra-cardiac thrombus resolution. These findings indicate that NOACs may be a non-inferior option for the treatment of LA, LAA, and LV thrombi in the future. Further investigation is encouraging given NOACs' rapid onset, short half-life, fixed dosing, and few interactions when compared to warfarin. Additional studies are needed to further elucidate our study findings.

P2-108

Impact of Left Ventricular Remodeling, Tissue Properties and Mitral Regurgitation Severity on Left Atrial Myocardial Function in Ischemic Mitral Regurgitation Assessed via Speckle Tracking Echocardiography

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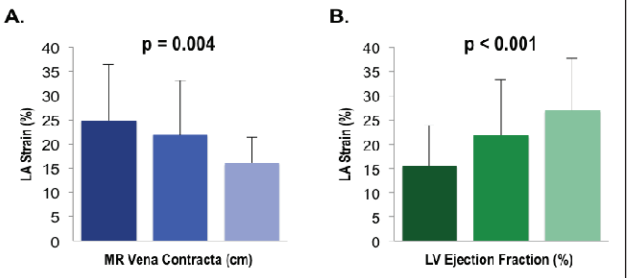
Background: Ischemic mitral regurgitation (iMR) provides a nidus for left atrial dysfunction (LA_{DYS}), which can now be quantified via echo derived strain. Impact of left ventricular (LV) tissue properties, function and volumetric remodeling on LA strain is unknown. **Methods:** Echo and stress cardiac magnetic resonance (CMR) were performed prospectively in iMR patients. Transthoracic echo quantified MR, LV and LA function (2 and 4C reservoir strain, EF, fractional area change [FAC]): LADYS was defined via established strain criteria (2C global longitudinal strain<23%). Stress CMR provided a reference for LV tissue ischemia and infarction. **Results:** 107 iMR patients (82% M; 68±10

yo) were studied; 63% had LA_{DYS}. LA_{DYS} pts had greater MR (vena contracta [VC]: 0.4±0.1 vs 0.3±0.1cm; p<0.001 | regurgitant fraction [RF]: 38±15 vs 31±13%; p=0.02), larger LA size (echo: 50±15 vs 33±9ml/m^2; p<0.001 | CMR: 66±19 vs 49±14ml/m^2; p<0.001), and lower LVEF (echo: 38±14 vs 51±13%; p<0.001 | CMR: 38±14 vs 51±13%; p<0.001) [**Table**]. Global LV tissue properties based on ischemia (14±10 vs 12±9% LV myocardium; p=0.6) and MI size (11±10 vs 10±9%; p=0.4) were similar between groups, as were corresponding regional LV indices (p=NS). LA 2C and 4C strain strongly correlated LA FAC and EF (r>0.90, p<0.001). In multivariable regression, LA strain was associated with MR severity (OR -0.3 per cm VC [CI (-38.8) - (-6.5)], p=0.007) and LVEF per 10% decrement (OR 0.7 [CI 1.7-4.3], p<0.001). LA strain decreased stepwise in relation to both MR and LVEF (**Figure**), and was 1.6-fold lower in pts with advanced (≥moderate) MR (25±11 vs 16±8%; p<0.001). Whereas all echo LA variables differed between pts with and without advanced MR (all p<0.001), magnitude of difference was ~1.5-fold greater for 2C (relative Δ58%) and 4C strain (Δ48%) than for FAC (Δ36%, Δ41%) and EF (Δ33%, Δ36%) in co-localized views. **Conclusions:** Among iMR patients, impaired LA strain is common and strongly associated with adverse LV remodeling and MR severity independent of LV infarct size and ischemia burden.

Imaging Characteristics				
	Overall (n=107)	**LA_{dys} +* (n=67)**	**LA_{dys} - (n=40)**	**p**
CARDIAC MAGNETIC RESONANCE				
LA area (cm^2)	28.8 ± 7.2	30.1 ± 7.1	24.2 ± 6.2	**<0.001**
LA volume (ml/m^2)	59.5 ± 19.1	65.8 ± 19.3	49.2 ± 13.7	**<0.001**
LV ejection fraction (%)	42.9 ± 15.2	37.8 ± 14.2	51.3 ± 12.8	**<0.001**
LV end-diastolic volume (ml)	201.7 ± 63.9	211.5 ± 68.4	185.6 ± 52.9	**0.004**
LV end-systolic volume (ml)	121.6 ± 61.8	138.2 ± 65.2	94.2 ± 44.3	**<0.001**
LV infarct size (%LV)	10.7 ± 9.7	11.3 ± 10.0	9.6 ± 9.0	0.4
Global ischemia burden (%LV)	13.1 ± 9.4	13.6 ± 10.1	12.4 ± 8.6	0.6
ECHOCARDIOGRAPHY				
LA dimension (cm)	4.4 ± 0.7	4.5 ± 0.8	4.2 ± 0.6	**<0.001**
LA area (cm^2)	24.3 ± 6.4	26.4 ± 6.2	20.8 ± 5.0	**<0.001**
LA volume (ml/m^2)	43.6 ± 15.4	49.8 ± 15.1	33.2 ± 9.2	**<0.001**
LA end-diastolic volume (ml)	77.3 ± 39.9	93.5 ± 40.8	50.1 ± 17.4	**<0.001**
LA end-systolic volume (ml)	130.9 ± 45.0	139.2 ± 47.3	116.9 ± 37.5	**0.001**
LA ejection fraction (%)	42.7 ± 14.7	34.2 ± 10.4	56.8 ± 8.7	**<0.001**
LA fractional area change (%)	30.9 ± 11.6	23.8 ± 7.7	42.6 ± 6.4	**<0.001**
LA 4C GLS (%)	18.9 ± 9.8	13.9 ± 6.8	27.4 ± 8.1	**<0.001**
LA 2C GLS (%)	21.5 ± 10.8	14.3 ± 5.3	33.2 ± 6.2	**<0.001**
LV ejection fraction (%)	42.0 ± 15.2	36.9 ± 14.0	50.7 ± 13.3	**<0.001**
LV end-diastolic volume (ml)	5.9 ± 0.6	5.9 ± 0.6	5.7 ± 13.3	**0.03**
LV end-systolic volume (ml)	4.7 ± 0.8	4.9 ± 0.9	4.2 ± 0.7	**<0.001**
MR severity grade (1-4)	1.6 ± 0.8	1.8 ± 0.9	1.3 ± 0.6	**0.001**
MR vena contracta (cm)	0.3 ± 0.1	0.4 ± 0.1	0.3 ± 0.1	**<0.001**
MR regurgitant fraction (%)	35.9 ± 14.4	38.4 ± 14.5	31.4 ± 13.3	**0.02**

Figure



P2-109

Minimal Left Atrial Volume and Prognosis Following Myocardial Infarction

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Background: The prognostic value of minimal left atrial volume indexed to body size following myocardial infarction (MI) has not been studied previously. The aim of this study was to determine the relative prognostic value of minimal left atrial volume index (LAVImin) compared to maximum left atrial volume index (LAVImax) following a first-ever MI. **Methods:** Consecutive patients admitted to a single tertiary referral centre with a first-ever non-ST-elevation-MI (NSTEMI) or ST-elevation-MI (STEMI) between Jaunuary 2013 and December 2014 were included. A comprehensive echocardiogram was performed early post- admission. LAVImax and LAVImin were determined using Simpson's biplane method from 2D apical windows. LAVmin ≥18mls/m2 and LAVImax ≥34mls/m2 were considered enlarged. Outcomes data were obtained from a statewide death registry**.** The primary endpoint was composite MACE (death/MI/heart failure) with all-cause mortality as a secondary endpoint. Nested Cox models were constructed to test the incremental value of LAVI to clinical variables and left ventricular ejection fraction (LVEF). **Results:** During the study period, 558 patients presented with a first-ever MI; after exclusions 392 were included in the study group. At a median follow-up of 24 months, there were 53 MACE events (13.5%) and 31 deaths (7.9%). On Kaplan Meir analysis, both LAVmin (log-rank χ^2 11.5, p=0.001) and LAVImax (log-rank χ^2 7.4, p=0.007) were associated with increased MACE. On Cox proportional hazards multivariate analysis, LAVImin (HR 2.42[95%CI 1.28-4.57],p=0.007) but not LAVImax (HR1.72[95%CI 0.94-3.18], p=0.084) was an independent predictor of MACE. Similarly, for all-cause mortality, on Cox proportional hazards multivariate analysis, LAVImin (HR 3.02[95%CI 1.21-7.52], p=0.018) but not LAVImax (HR 1.71[95%CI0.78-3.73],p=0.177) was an independent predictor. Using nested Cox models, the addition of LAVImin, but not LAVImax, to significant clinical variables and LVEF produced a significant increment in model power for both MACE and all-cause mortality. **Conclusion:** LAVImin is an independent predictor of outcomes following MI, and may be superior to LAVImax in this regard. Larger studies are needed to confirm the latter finding.

P2-110

Regional Longitudinal Strain May Help to Reveal the Microvascular Dysfunction After Primary Percutaneous Coronary Intervention in Patient with ST-Segment Elevation Myocardial Infarction

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Background: Microvascular function is useful for predicting long-term prognosis in patients with ST-segment elevation myocardial infarction (STEMI). This study sought to investigate the relationship between regional myocardial function and the degree of microvascular dysfunction. **Methods:** Forty-seven consecutive patients with STEMI were recruited. The culprit lesions of all individuals were in left anterior descending coronary artery (LAD) qualified by coronary angiography. Microvascular dysfunction was assessed by index of microcirculatory resistance (IMR), along with fractional flow reserve. Using the results of IMR, we divided them into 22 patients with severe (≥ 40) and 25 patients without or slightly microvascular dysfunction (< 40). Echocardiographic examinations were taken at before and 1-month follow-up after primary percutaneous coronary intervention (PCI). Store the images of apical 2-, 3-, 4- chamber views for the subsequent analysis. Longitudinal strains were evaluated in all the patients using two dimensional speckle tracking echocardiography (2D-STE). Then we compared the differences of all the strain parameters between the two groups. Regional longitudinal strain in LAD territory (RLS-LAD) was calculated as the mean peak systolic longitudinal strain of segments subtended by the LAD. **Results:** The values of RLS-LAD were similar between two groups before PCI. However, the patients with severe microvascular dysfunction had relatively lower values of RLS-LAD at 1-month follow-up after PCI, and the differences between the two groups were significant (-10.7 ± 2.7 vs. -15.8 ± 3. 5 %, P < 0.05). The RLS-LAD showed good performance in detecting patients with severe microvascular dysfunction, with area under the receiver operating characteristic curve of 0.92. A RLS-LAD cutoff value of -12.3 % showed optimal sensitivity and specificity (90.0/82.0%). **Conclusion:** In patients with STEMI, regional longitudinal strain acquired by 2D-STE might enable to detect patients with severe microvascular dysfunction, which could provide additional help for further therapy.

P2-111

Morbidity in Takotsubo Cardiomyopathy: Echocardiographic Predictors of Clinical Outcomes in a Detailed Cohort

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Background: Once considered a benign clinical disorder, Takotsubo cardiomyopathy (TCM) has been demonstrated in large registries to confer similar cardiovascular outcomes as acute coronary syndrome (ACS). **Methods:** We queried the electronic medical record for TCM patients from January 2012 - December 2014 in our integrated health system. Diagnosis was confirmed by reviewing, in detail, the clinical data, coronary angiography, and echocardiography. The cohort was compared to a matched ACS population cohort. Baseline characteristics, in-hospital and clinical outcomes were collected up to 1 year. **Results:** There were 207 patients with TCM in the study period, 179 (86.5%) were female, mean age 66.5 ± 13.3 years. The most common morphology on echocardiogram was apical in 135 (65%) cases, mid-ventricular in 58 (28%), basal in 8 (4%), and focal in 6 (3%) cases. In-hospital mortality (4.3% vs 1.4%, p 0.027) and

major adverse cardiac events (MACE) (57.0% vs 36.7%, p<0.001) were higher in TCM than ACS patients. At 1 year, there was no difference in mortality, but higher 1-year MACE for TCM patients (30.9% vs 23.2%, p<0.038). There were no statistical differences in-hospital MACE between morphologies (apical n=45 (33%) vs. non-apical (n=19 (26.5%) p=0.303). On multivariate analysis, predictors of hospital MACE were driven by clinical characteristics (pulmonary disease, secondary TCM, admitting diagnosis of infection) and not by TCM morphology. The only echocardiographic characteristic that predicted MACE was LV ejection fraction < 45% (Odds Ratio 2.89 [95% CI 1.2 - 7.2] p=0.026). There were 9 (4.3%) cases of recurrent TCM, of which 4 patients developed a different morphology of TCM at second presentation. TCM patients prescribed beta-blockers on discharge had significantly lower readmission, 1-year MACE, and mortality. **Conclusions:** TCM patients had a high rate of in-hospital and follow-up clinical events, and certain clinical characteristics predicted worse prognosis, regardless of morphology on echocardiography. The only echocardiographic characteristics that predicted in hospital MACE was LVEF < 45%.

P2-112

Detection of Exercise-Induced Abnormalities of Myocardial Deformation in Patients with Unrepaired Anomalous Aortic Origin of the Right Coronary Artery

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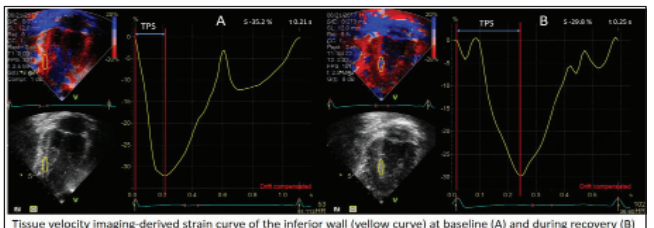
Background: Congenital coronary artery anomalies are rare but may have significant clinical repercussions including sudden death. The management of asymptomatic patients with anomalous aortic origin of the right coronary artery (AAORCA) is controversial and evidence-based risk stratification recommendations are lacking. Specifically, the role of stress imaging in patients with AAORCA to evaluate risk is unclear. Based on data in adults with right coronary atherosclerotic disease, we hypothesized that at least some patients with AAORCA may have exercise-inducible abnormalities in regional myocardial deformation detectable by echocardiography. **Methods:** 21 patients with unrepaired AAORCA and 11 controls who had treadmill exercise stress echocardiography (ESE) were studied. Regional wall motion, assessed by visual inspection, and tissue velocity imaging were evaluated at baseline and during recovery. Time to peak left ventricular (LV) systolic longitudinal strain corrected for heart rate (TPSc) for the inferior wall was calculated and the post to pre exercise ratio (TPScR) was obtained. A secondary analysis evaluated LV inferior wall TPScR from 12 patients who had ESE following surgery for AAORCA. Patients were compared to controls using the 1-tailed Student's t test, with the level of significance set at P < .05. **Results:** No regional wall motion or ECG abnormalities were noted at rest or after peak exercise in patients or controls. TPS following exercise was delayed compared to baseline in the inferior wall of some patients with unrepaired AAORCA (Figure 1). Mean TPScR was significantly higher for patients than controls (0.99 ±0.40 vs. 0.76 ±0.18, p = 0.047). There was no significant difference in inferior wall TPScR between repaired patients and controls (p = 0.23). **Conclusion:** In patients with unrepaired AAORCA, time to peak strain following exercise is prolonged in segments supplied by the right coronary artery, presumably due to induced ischemia not detectable by wall motion analysis or ECG changes. This is the first demonstration of an exercise-induced abnormality of ventricular function in AAORCA. Further work is needed to ascertain the potential role of this finding in risk assessment.



Tissue velocity imaging-derived strain curve of the inferior wall (yellow curve) at baseline (A) and during recovery (B) in a patient with unrepaired AAORCA undergoing exercise stress echo. Time to peak strain is delayed post exercise compared to baseline.

P2-113

Two-Dimensional Area-Length Method Better Estimates Actual Left Ventricular Weight Compared to M-mode Linear Method in Swine Models of Ischemic Heart Disease

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Background: Left Ventricular (LV) mass is an essential risk factor and a strong predictor of cardiovascular diseases. M-mode and two-dimensional echocardiography (2DE) offer fast and cost-efficient estimation of LV mass. However, their accuracy against actual LV weight in diseased heart has not been systematically evaluated. The aim of this study was to examine agreement and correlation of the LV mass estimated by M-mode-based linear method and 2DE-based area-length method against actual LV weight. **Methods:** Yorkshire swine underwent induction of various etiologies of sub-acute and chronic heart failure including ischemic heart disease (IHD), volume-overload, and pressure-overload. LV mass was measured by M-mode-based linear method as well as 2DE-based area-length method and were compared to the actual LV weight measured at autopsy. Simple linear regression and the Bland-Altman analysis were performed. Impact of myocardial infarction was evaluated by separately analyzing those with and without IHD. **Results:** Twenty-seven pigs without any cardiac diseases, 32 pigs with non-IHD heart failure, and 195 pigs with IHD were included in the analysis (total n = 254). A strong positive linear relationship to the LV weight was found with area-length method (r = 0.82, p < 0.001), whereas moderate linear relationship was found with linear method in overall population (r = 0.68, p < 0.001). There was a statistically significant difference between the two correlation coefficients (p = 0.0003). While both methods demonstrated similar strong linear relationships to the LV weight in pigs without IHD, area-length method exhibited superior correlation and agreement in pigs with IHD. The Bland-Altman analysis revealed significant overestimation using linear method as the LV weight increased. **Conclusion:** Both linear and area-length methods provide good estimation of LV weights in pig models of heart diseases. Area-length method offers better estimation compared to the linear method in pigs with IHD.

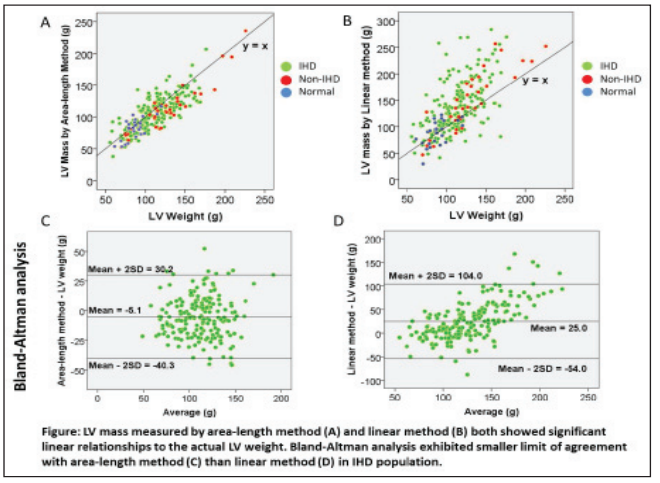

Figure: LV mass measured by area-length method (A) and linear method (B) both showed significant linear relationships to the actual LV weight. Bland-Altman analysis exhibited smaller limit of agreement with area-length method (C) than linear method (D) in IHD population.

P2-114

Echocardiographic Indices of Regional Deformation Predict Left Ventricular Thrombus following Anterior Wall ST-Segment Elevation Myocardial Infarction

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Background: Left Ventricular (LV) thrombus formation often occurs between 24 hours and 2 weeks after anterior wall ST-segment elevation myocardial infarction (AW-STEMI). Speckle tracking imaging (STI) parameters have been used to quantify LV contractility by assessing global and regional LV strain. We sought to test if STI derived strain parameters were associated with LV thrombus after reperfusion therapy for AW-STEMI. **Methods:** From the Montefiore Medical Center cardiology database we identified 74 subjects who had AW-STEMI and had transthoracic echocardiography (TTE) performed within 24 hours of reperfusion therapy between 2008 - 2014. TTE were reviewed for the presence of LV thrombus and the studies were re-analyzed for STI regional and global strain parameters using Cardiac Performance Analysis - Tomtec software. **Results:** Study subjects were age 59 ± 13 years and 31% were female. Those with LV thrombus (n=16) more frequently had chest pain for >24 hours (44% versus 16%, p < 0.02), lower ejection fraction (31 ± 6% versus 35 ± 6%, p = 0.03), and more frequently had aneurysmal apex (22% versus 0%, p < 0.01) than those without LV thrombus. Global longitudinal strain was worse (less negative) among patients with LV thrombus (-2.3 ± 4.4% versus -5.1 ± 3.9%, p = 0.04). Regional strain was shown to be worse in the mid anterior (-8.0 ± 3.7 versus -10.6 ± 4.4, p = 0.05) and mid anteroseptal walls (-7.7 ± 3.02 versus -10.9 ± 4.2, p = 0.01) in subjects that had LV thrombus. No differences were noted in the subjective wall motion score for the LV apical segments (3.2 ± 0.5 versus 3.0 ± 0.5, p = 0.12) and the non-apical segments (14.2 ± 4.9 versus 14.3 ± 4.6, p = 0.94) between those with and without LV thrombus respectively. **Conclusion:** In subjects with LV thrombus following AW-STEMI, STI strain indices detected subtle reductions in the mid anterior and mid anteroseptal segments that were not perceived by subjective assessment of wall motion. Routine use of these parameters in subjects with AW-STEMI may therefore improve prediction of thrombus development.

Table of Results			
	LV thrombus	Non LV thrombus	P value
Global longitudinal strain (%)	-2.3 ± 4.4	-5.1 ± 3.9	0.04
mid anterior strain (%)	-8.0 ± 3.7	-10.6 ± 4.4	0.05
mid anteroseptal strain (%)	-7.7 ± 3.02	-10.9 ± 4.2	0.01
LV apical wall motion score	3.2 ± 0.5	3.0 ± 0.5	0.12
LV Non-apical wall motion score	14.2 ± 4.9	14.3 ± 4.6	0.94

P2-115

Tako-tsubo Syndrome in Acute Myocardial Infarction: Tako-Effect

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Background: Tako-tsubo syndrome (TTS) is a transitional left ventricular dysfunction which is commonly confused with acute myocardial infarction (AMI). The diagnosis of TTS in the setting of AMI with significant coronary stenosis is debatable. The purpose of this study is **t**o evaluate the systolic and diastolic ventricular functions, hemodynamic consequences, short-term (30 days) and long term (1 and 5 years) cardiovascular outcomes in AMI with and without TTS. **Methods:** Between 11/01/2012 and 01/31/2016, 111 patients with left anterior descending artery stenosis causing anterior ST-elevation MI were studied. They were classified into 2 groups: Patients with MI and TTS-like contractile dysfunction and regional wall motion abnormality that extend beyond the territory of the culprit artery (we name it Tako-effect) (31 patients) and patients with MI without Tako-effect (80 patients). Patients with MI and Tako-effect were also compared to 66 consecutive matched patients with TTS without significant coronary artery stenosis. **Results:** Tako-effect patients had significantly lower left ventricular ejection fraction (38.5 ± 6.8% vs. 47.7 ± 8.7%, $P = 0.000$), and significantly higher Tei-index (0.54 ± 0.17 vs. 0.37 ± 0.15, $P = 0.000$) compared to non Tako-effect patients. In contrast, they have no significant difference in the left ventricular filling pressures and right ventricular functional parameters. Also, there was no significant difference in the short term outcomes including hypotension, cardiogenic shock and 30-days mortality between both groups. The long term follow up (1 year and 5 years) showed higher major adverse cardiac events rate in the Tako-effect group mainly driven by the rate of MI and ischemia-driven target lesion revascularization [20 patients (64.5%) vs 34 patients (42.5%), $P = 0.037$]. Tako-effect group also had increased re-hospitalization rate [21 patients (67.7%) vs 36 patients (45.0%), $P = 0.031$]. Patients with MI and Tako-effect had similar LV systolic and diastolic functions and right ventricular functional parameters compared to patients with TTS without significant coronary artery stenosis. **Conclusions:** Patients with acute anterior ST-elevation MI may develop concomitant TTS. Patient with MI and Tako-effect have similar short term but worse long term cardiovascular outcomes compared to Non Tako-effect patients.

P2-116

Inconclusive Cardiac Stress Echocardiography and The Utility of The Double Product in Predicting Outcomes: Early Results

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Background: Stress echocardiography (SE) is one of the frequently used methods in assessing for coronary ischemia in patients with chest pain. Inconclusive SE, defined as the inability to achieve ≥ 85% of maximal predicted heart rate (MPHR), poses a challenge for clinicians. The aim of our study is to evaluate patients with submaximal SE and see if the value of the double product (DP) could further delineate long term risk better in this patient population. **Methods:** Six hundred and forty five patients who underwent either chemical or treadmill SE between Jan-June 2013 who had submaximal (< 85%) MPHR were retrospectively reviewed. Demographics, medical history, and cardiac stress testing reports were collected. Then, 4 years adverse outcomes, defined as a development of systolic heart failure, myocardial infarction, and death were documented and analyzed, and additional downstream testing (repeat stress testing, myocardial perfusion imaging, or coronary angiography) were collected. **Results:** Mean age was 59.6 years, and 55% were males. Caucasians represented 47%, and 46% were African Americans (AA). History of myocardial infarction and heart failure was reported in 33% and 19%, respectively. Composite outcome was found in 132 (20%) of all patients. Patients with adverse events were older (64.1, vs. 58.5, P<0.001), males (65.9% males vs. 34.1% females, P 0.004), Caucasian (54.6% Caucasians, vs. 39.4% AA, P 0.044), and with higher incidence of CAD, and CHF. The univariate odds ratio for the relationship between DP and the composite outcome indicated that for every 1,000-unit increase in DP, the odds of an adverse outcome decrease by 9.1% ([5.5% - 12.6%], P<0.001)**. Conclusion:** Inconclusive SE currently poses a dilemma and many times leads to further testing to reach conclusive decisions for presence or absence of CAD Our study showed that younger, AA females, with no history of CAD or CHF, who were able to achieve a higher value of DP, have a favorable long term outcome with less subsequent adverse events or death after 4 years. Thus patients with these characteristics with a negative submaximal SE could be triaged for observation with additional evaluation reserved if they continue to have symptoms. Although traditionally a DP of 24,000 is considered adequate workload DP response may vary for pharmacologic versus exercise stress testing, and thus may help stratify patients when viewed as a continuum.

P2-117

Echocardiographic Findings in 102 Centenarians

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Background: Number of centenarians has been on the rise. In 2015, 72,000 centenarians lived in the United States and this number is expected to surpass 1 million by 2050. Cardiovascular disease (CVD) remains the most common cause of death in this population. However, studies of CVD in this population are relatively scarce and there is evidence that CVD is underreported in the oldest old. The goal of this study was to explore the morphologic and functional cardiac abnormalities in centenarians as evaluated by echocardiography. **Methods:** We retrospectively reviewed the echocardiograms of 102 consecutive centenarians aged 100 to 105 (mean 100.4 ± 1.4) years at the time of referral [85% women, 87% hypertensive, 17% diabetic, 25% hyperlipidemic, body surface area 1.2-2.1 (1.6 ± 0.2) m^2, body mass index 15.1-41.7 (24.9±4.5) kg/m^2, 33% overweight, 12% obese] referred to our laboratory for echocardiography between 2010 and 2017. **Results:** The following CVD were present by history: heart failure 56%, coronary artery disease 23% (prior PCI 7%, prior CABG 2%), peripheral arterial disease 7% and cerebrovascular accident 24%. Electrocardiographic atrial fibrillation was present in 32%. Echocardiographic abnormalities included left ventricular (LV) dilation (1%), concentric remodeling (47%), LV hypertrophy (46%) including 18% with severe LV hypertrophy, regional wall motion abnormality (21%), decreased LV ejection fraction (21%), abnormal (other than age-appropriate) indices of diastolic function (50%), left atrial (LA) dilation (60%), right ventricular dilation (17%), tricuspid regurgitation peak velocity ≥3 m/sec (49%), and pericardial effusion (9%). Mild, moderate and severe aortic stenosis was present in 14%, 12%, and 16%, respectively. Mild or moderate calcific mitral stenosis was noted in 9%. Significant (>mild) regurgitation was noted in mitral (37%), aortic (13%) and tricuspid (40%) valves. **Conclusion:** Structural and functional cardiac abnormalities are commonly noted among centenarians referred for echocardiography. Overall, at least one echocardiographic abnormality was noted in 99% of the centenarians studied.

P2-118

A Comparison of Long-Term Mortality Prediction Using Two Methods of EF Assessment from the National Echo Database Australia (NEDA)

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Background: Echocardiography (echo) is well established in the evaluation of Left Ventricular Ejection Fraction (LVEF). Traditional methods rely on geometric assumptions not valid in all patients, whereas other measures suffer from challenges in image quality that may undermine their anatomic and geometric superiority. We evaluated the prognostic impact of two established methodologies for calculating LVEF: Basal long axis 2D Teicholz method (Teich) and the Apical Biplane Method of Disks (MOD).
Methods: NEDA contains echo measurement data (years 1997 -2017 inclusive) from laboratories (N=10) across Australia (>530,000 echos) with linkage to the National Death Index (NDI). Data from 352,844 individuals (186,820 men, 60.8±18.0 years and 166,024 women, 60.9±19.2 years) had a mean follow up of 5.4 years per person and 63,142 fatal events. We compared Teich (with linked echo and survival data in 145,785 cases) and MOD (102,850 cases) in predicting all-cause mortality at various time points (1-year and 5-year) across the full distribution of LVEF values. This included all cases, and those with the lowest quintile of LVEF (≤55%). **Results:** In age- and sex-adjusted Cox-Proportional Hazard Models, both methods performed well in delineating the risk of all-cause mortality for all cases. The Teich method performed slightly better: Adjusted HR for mortality in the lowest versus highest quintile of LVEF was 1.89 (95% CI 1.80 to 1.98) for MOD vs 2.00 (95% CI 1.93 to 2.07) for Teich (p<0.001 for all outputs). The sensitivity and specificity of age- and sex-adjusted multiple logistic regression models using Teich were superior in predicting all-cause mortality. For example, the sensitivity and specificity of the model using Teich to predict 5-year mortality in 14,175 cases was 72.2% and 78.5%, respectively (adjusted odds ratio for the lowest versus highest quintile of LVEF being 2.63, 95% CI 2.29 to 3.00; p<0.001). This compared to a sensitivity and specificity 66.5% and 75.9%, respectively (equivalent adjusted odds ratio 2.16, 95% CI 1.86 to 2.59; p<0.001) derived from 15,192 cases with MOD. **Conclusion:** LVEF (on an age- and sex-adjusted basis) is a powerful predictor of short-to long-term mortality with a steep gradient of increasing risk in those individuals with a LVEF <55%. However, in like-for-like comparisons, within a large population, Teich appears to be a stronger correlate of mortality both within the entire spectrum of LVEF values and, specifically, among those with impaired EF. For an individual patient, the best method for EF assessment may be dependent on initial image quality.

Poster Session 2 (P2)

Monday, June 25, 2018

P2-119

RV Function and Afterload. Is the Sum Greater than the Parts?

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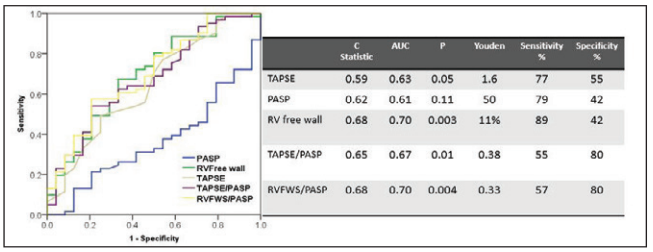
Introduction: RV free wall strain (RVFWS) has shown promise as a strong outcome marker in PAH. However, RV function is afterload-dependent, and RV to PA coupling can be measured with echocardiography by calculating the ratio of systolic function to pulmonary pressure (PASP). TAPSE/PASP ratio has an evidence base for predicting outcome in pre and post capillary hypertension. We sought to determine if the RV function to pressure ratio markers add significantly to prediction of outcome, above that of the individual outcome variables. Our hypothesis was TAPSE/PASP would be a greater predictor than PASP and TAPSE alone. **Methods:** 95 pts (73%F 63±14) with invasively diagnosed PAH underwent echocardiography and were followed for 118±50 months, over which time, 29 died. Velocity vector imaging was used to measure RVFWS, TAPSE was measured as the displacement of the tricuspid annulus over systole, PASP was estimated from the TR max velocity jet combined with the RAP from IVC size. Kaplan-Meier curves were used to express survival, with log rank testing of bivariate variables predictive ability. Cox regression was used to identify the independent association of these parameters with outcome, with model strength assessed with Harrell's C statistic. ROC curves were created, with Youden index used to identify the cut off values for predictors. **Results:** RVFWS (HR 0.89(0.83; 0.95)p=0.001) and PASP (HR 1.02(1.0;1.03)p=0.05) were significantly associated with death, with TAPSE (HR 0.47(0.21-1.03),p=0.06) of borderline significance. TAPSE/PASP was significant (HR 0.09(0.1;0.70)p=0.02) as was RVFWS/PASP (HR 0.04(0.004;0.39),p=0.006. ROC AUC showed markers to have mild-moderate discriminative ability (Figure 1) . C-statistics showed a small increase in predictive ability from TAPSE (0.59) and PASP (0.62) to the TAPSE/PASP ratio (0.65), with this not shown with the RVFWS (0.68) to RVFWS/PASP (0.68) ratio. The Youden index calculated for TAPSE/PASP (0.003) and RVFWS/PASP (0.001) were significant for predicting outcome. **Conclusion:** The combined variable of TAPSE/PASP showed a small increase in predictive ability above TAPSE and PASP alone. RVFWS/PASP and TAPSE/PASP showed good discrimination for predicting outcome.



	C Statistic	AUC	P	Youden	Sensitivity %	Specificity %
TAPSE	0.59	0.63	0.05	1.6	77	55
PASP	0.62	0.61	0.11	50	79	42
RV free wall	0.68	0.70	0.003	11%	89	42
TAPSE/PASP	0.65	0.67	0.01	0.38	55	80
RVFWS/PASP	0.68	0.70	0.004	0.33	57	80

P2-120

Left Ventricular Diastolic Function Predicts Outcomes in Patients with Heart Failure - A Comparison Between 2009 and 2016 American Society of Echocardiography Recommendations

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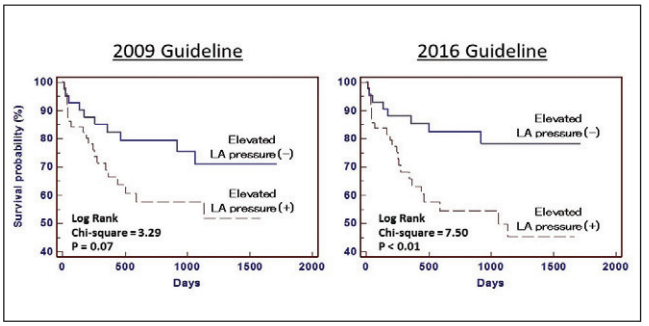
Background: Heart failure (HF) represents a major health problem worldwide, especially in an aging society. Echocardiography has an important role in the management of heart failure. The practical gold standard of grading of diastolic dysfunction (DD) is echocardiography. However, the long-term predictive value of the new proposed algorithm in the updated 2016 guidelines of the American Society of Echocardiography to assess DD has not been validated. The aim of this study was to compare the predictive value of the 2009 and 2016 DD grading system on cardiovascular outcomes in patients with heart failure with reduced and preserved ejection fraction (HFrEF and HFpEF). **Methods:** We did a retrospective cohort study between January 2013 and October 2017. We enrolled 192 hospitalized HF patients who patients were divided into HFrEF (EF<45%, n=99) and HFpEF (EF ≥45%, n=93). The primary endpoint was readmission for heart failure (HF). **Results:** There were 57 hospital readmissions during 23±16 months of follow-up. The Kappa score between 2009 and 2016 guidelines was 0.66. In the HFrEF cohort, Grade II/III DD by 2009 and 2016 guidelines were similarly associated with the endpoint (2009 guideline; Chi-square, 5.68: p =0.02, 2016 guideline; Chi-square, 6.29: p =0.01). In the HFpEF cohort, only the Grade II/III DD of the 2016 guideline was significantly correlated with the endpoint (Chi-square, 7.50: p < 0.01). **Conclusions:** The grading of DD at discharge predicted readmission for HF. 2016 DD grading algorithm can be useful for the assessment of readmission risk in patients with HFpEF and HFrEF.



P2-121

Diagnostic Performance of Echocardiographic Linear Fractional Shortening for Quantification of Right Ventricular Systolic Function as Compared to Traditional and 2D-Strain Assessment—A Cardiac Magnetic Resonance Validation Study

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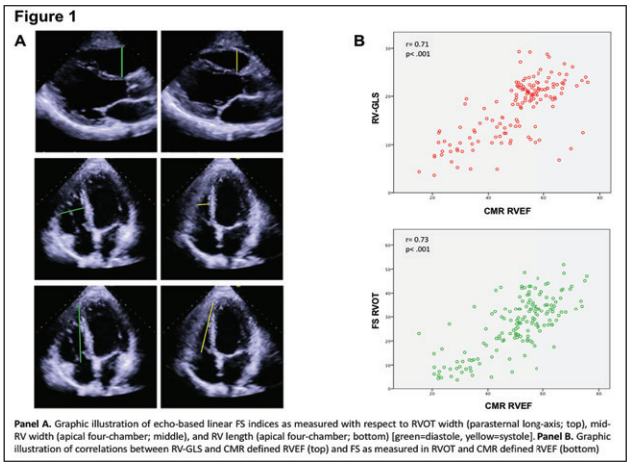
Background: Little is known about echo-based linear fractional shortening (FS) for detection of right ventricular dysfunction (RVdys); in particular, no data are available comparing RV FS with RV 2D speckle tracking strain assessment. **Methods:** The population comprised left ventricular dysfunction patients with and without RVdys (EF<50%) on cardiac magnetic resonance (CMR): Echo included standard RV indices (FAC, TAPSE, RV-S´), as well as FS in parasternal long-axis (RV outflow tract [RVOT]) and apical four-chamber views (RV width, RV length; **Fig. 1A**) and RV global longitudinal strain (RV-GLS) via speckle tracking in apical 4-chamber view. **Results:** We studied 168 patients undergoing echo and CMR (3±3 days); FAC (46±9 vs 28±11%), TAPSE (1.9±0.4 vs 1.5±0.3cm), RV-S´ (11.4±2.3 vs 10.0±2.6cm/sec) and RV-GLS (20.8±4.1 vs 11.8±4.1%) were lower among RVdys patients (all p≤.001), as were FS indices (RVOT 32±8 vs 17±10 | RV width 40±11 vs 22±12 | RV length 16±5 vs 9±4%; all p<.001). FS indices yielded similar magnitude of correlation with CMR RVEF (r=.73-.56) as did RV-GLS (r=.71) (**Fig. 1B**) and FAC (r=.70), which were higher than TAPSE (r=.47) and S´ (r=.31; all p<.001). FS indices decreased stepwise vs CMR RVEF tertiles, as did RV-GLS (all p<.001). In multivariate analysis, FS measured in the RVOT (regression coefficient 0.51 [CI 0.37-0.65]), RV width (0.30 [0.19-0.41]), and RV length (0.45 [0.20-0.71]; all p≤.001) were independently associated with CMR RVEF. Among FS indices, RVOT measurements yielded the highest diagnostic performance for CMR-defined RVdys (AUC: 0.87 [CI 0.80-0.94]), approaching that of RV-GLS (AUC: 0.94 [CI 0.91-0.98]; both p<.001) (**Fig. 2**). **Conclusion:** RV linear FS provides RV functional indices that parallel CMR RVEF. In particular, FS measured in parasternal long-axis RVOT yields good diagnostic performance as compared to RV-GLS, supporting the use of easily obtainable linear indices for RV functional assessment when more time-consuming techniques like RV-GLS are not available or not possible to be applied.



Panel A. Graphic illustration of echo-based linear FS indices as measured with respect to RVOT width (parasternal long-axis; top), mid-RV width (apical four-chamber; middle), and RV length (apical four-chamber; bottom) [green=diastole, yellow=systole]. **Panel B.** Graphic illustration of correlations between RV-GLS and CMR defined RVEF (top) and FS as measured in RVOT and CMR defined RVEF (bottom)

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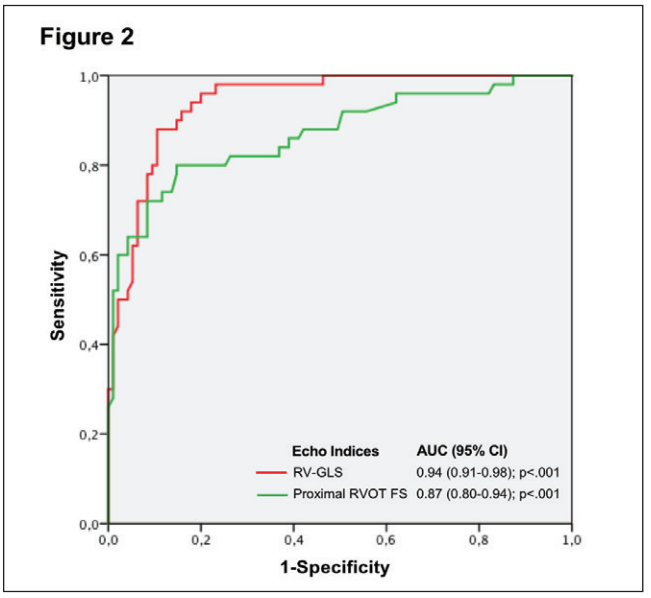

P2-122

Gender Differences in the Association of Carotid Arterial Resistive Index with Left Ventricular Diastolic Function

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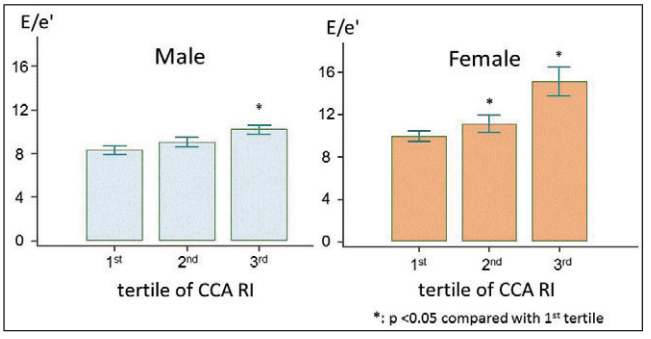
Background: Previous reports showed that carotid arterial resistive index (RI) was associated with the degree of generalized atherosclerosis and a sensitive marker of vascular dysfunction. The relationship between atherosclerosis and left ventricular (LV) diastolic function has been previously reported. Recently, there has been increasing recognition of the gender differences in LV diastolic function. Thus, the aim of this study was to assess the gender differences in relationship between LV diastolic function and carotid arterial RI. **Methods:** A total of 515 subjects (304 male and 211 female; mean age 69 years) were recruited from our vascular laboratory database from January 2017 to December 2017. Carotid ultrasonography and transthoracic echocardiography were performed on all subjects. RIs in common carotid artery (CCA) were measured, and their relationships with LV diastolic function (E/e' ratio) were assessed after adjustment for covariates. **Results:** There was no difference of cardiovascular etiologies between male and female groups. The mean RI in CCA was 0.78±0.06 and E/e' was 10.1±4.9. The relationship between RI in CCA and LV diastolic function (E/e') was shown in **Figure**. A direct linear association was seen between increasing degrees of RI in CCA and worsen diastolic function especially in female. After multiple linear regression analysis, higher RI remained independently related to higher E/e' only in female ($p < 0.05$). **Conclusion:** These findings demonstrate that carotid arterial resistance closely related to LV diastolic function in female. The gender-dependent relation between carotid arterial resistance and LV diastolic function may be an insight of mechanism in gender difference of heart failure.



P2-123

Left Ventricular Strain and Synchrony in Children: Reference Values Derived from a Large Normal Pediatric Cohort

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Background: Left ventricular strain and synchrony have clinical importance in congenital and acquired heart diseases in adults and children. However, normal values for these values are lacking in large pediatric cohorts, particularly using the most popular pediatric echocardiographic platform. Therefore we aimed to determine normal values of strain and synchrony parameters in children and young adults using Philips equipment. **Methods:** High frame rate 2D transthoracic echo images were retrospectively analyzed. Included subjects were less than 21 years old with structurally and functionally normal hearts, and no other abnormalities with cardiovascular impact. Philips QLAB v10.5 was used to measure global and segmental longitudinal (LS) and circumferential (CS) strain and synchrony based on apical 4, 2, and 3-chamber (AP 4, 2, 3) and mid-wall short-axis (SAX-M) views. Synchrony measures included time-to-peak strain standard deviation, maximal wall delay, and cross-correlation mean segmental delay; these were compared both in native form and with heart rate correction (divided by √RR). **Results:** Data were included from 312 subjects (40% female, mean age 10.2±5.8y, age range 3d-20.5y). Overall, mean strain values were: AP4 -24.4%; AP2 -24.2%; AP3 -24.6%; SAX-M -25.8%. All components of global and segmental LS became less negative with increasing age and BSA ($p<0.001$ for all); global CS did not vary significantly with age or BSA (Figure 1). Most parameters of longitudinal, but not circumferential, synchrony varied significantly with age (Table 1); after HR correction, however, most of these differences were no longer present. **Conclusion:** We present ranges of pediatric strain and synchrony parameters in a normal pediatric cohort based upon the Philips platform. Global and segmental LS become less negative with age, while CS does not. Age-related differences in parameters of ventricular synchrony became less pronounced with HR-correction.

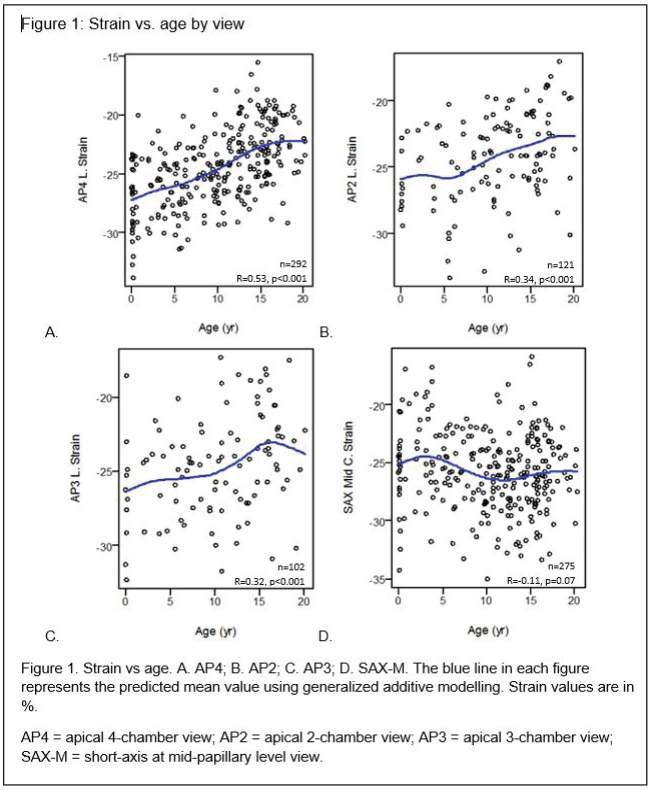

Figure 1. Strain vs age. A. AP4; B. AP2; C. AP3; D. SAX-M. The blue line in each figure represents the predicted mean value using generalized additive modelling. Strain values are in %.

AP4 = apical 4-chamber view; AP2 = apical 2-chamber view; AP3 = apical 3-chamber view; SAX-M = short-axis at mid-papillary level view.

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Table 1. Synchrony assessment by View and Age Group (Median (IQR))

View	Method	< 1yr	1-5 yr	>5-10 yr	>10-14 yr	>14-18 yr	≥ 18 yr	p
AP4	n	32	35	64	70	76	15	
	TTP-SD	2.3 (1.0, 7.9)	9.6 (2.1, 16.5)	17.4 (4.6, 24.3)	12.8 (2.0, 23.9)	17.8 (3.1, 27.6)	15.1 (1.7, 20.8)	<0.001
	MWD	3.0 (0.0, 14.0)	25.0 (0.0, 49.0)	49.5 (17.5, 62.0)	34.5 (12.0, 63.0)	40.5 (14.5, 69.5)	47.0 (16.0, 63.0)	<0.001
	XCorr MD	6.0 (4.5, 9.0)	7.0 (6.0, 10.0)	10.5 (7.0, 14.0)	11.0 (8.0, 15.0)	11.0 (8.0, 15.0)	9.0 (7.0, 11.0)	<0.001
	cTTP-SD	3.9 (1.6, 14.9)	12.8 (2.6, 21.5)	20.9 (4.0, 29.0)	13.0 (2.2, 25.2)	19.8 (3.4, 28.2)	16.4 (6.0, 23.4)	0.027
	cMWD	0.0 (0.0, 17.3)	33.1 (0.0, 59.2)	58.0 (18.0, 70.7)	38.3 (14.0, 64.9)	53.4 (15.6, 71.1)	51.1 (21.1, 63.9)	0.001
	cXCorr MD	9.5 (6.8, 13.1)	9.4 (7.9, 13.3)	12.2 (7.9, 16.0)	12 (9.3, 16.1)	10.9 (8.8, 15.9)	9.5 (7, 13.7)	0.115
AP2	n	10	10	21	30	36	8	
	TTP-SD	1.1 (0.5, 10.1)	14.2 (3.0, 19.1)	22.9 (6.9, 27.1)	10.2 (2.0, 27.2)	16.3 (3.0, 29.0)	20.0 (6.9, 35.9)	0.011
	MWD	0.0 (0.0, 34.0)	38.0 (0.0, 60.0)	58.0 (26.0, 76.0)	55.0 (15.0, 82.0)	24.5 (7.0, 74.0)	39.0 (13.5, 74.5)	0.066
	XCorr MD	4.5 (3.0, 8.0)	10.0 (8.0, 14.0)	9.0 (5.0, 12.0)	9.5 (5.0, 13.0)	9.5 (8.0, 13.5)	9.0 (5.5, 13.0)	0.119
	cTTP-SD	1.7 (0.8, 17.9)	10.8 (4.1, 26.8)	25.1 (14.4, 32.1)	19.1 (1.9, 32.0)	16.3 (3.2, 28.0)	24.7 (10.0, 34.8)	0.035
	cMWD	0.0 (0.0, 56.8)	49.2 (0.0, 80.0)	66.2 (35.0, 82.6)	62.3 (12.2, 77.0)	25.9 (13.8, 74.6)	52.6 (16.7, 74.2)	0.241
	cXCorr MD	7.3 (4.7, 11.6)	13.5 (10.9, 18.8)	10.8 (6.6, 14.3)	10.3 (6.2, 13.4)	10.1 (8.4, 14.5)	9.2 (5.6, 12.7)	0.351
AP3	n	10	10	24	26	26	6	
	TTP-SD	1.4 (0.8, 6.6)	3.3 (1.5, 16.0)	15.1 (8.3, 23.2)	11.4 (2.5, 17.0)	15.1 (4.1, 27.3)	29.7 (17.5, 32.1)	0.002
	MWD	7.5 (0.0, 20.0)	22.0 (0.0, 45.0)	47.0 (24.0, 60.0)	37.5 (0.0, 54.0)	40.0 (15.0, 79.0)	78.5 (47.0, 82.0)	0.026
	XCorr MD	6.0 (3.0, 8.0)	8.0 (6.0, 9.0)	8.5 (7.0, 13.0)	10.5 (8.0, 14.0)	11.0 (7.0, 19.0)	9.0 (8.0, 12.0)	0.004
	cTTP-SD	1.7 (1.0, 6.4)	7.6 (1.9, 27.5)	14.9 (7.7, 27.2)	15.0 (4.3, 21.4)	16.5 (4.5, 30.0)	31.6 (15.6, 34.1)	0.026
	cMWD	9.7 (0.0, 27.6)	23.2 (0.0, 61.7)	54.2 (29.6, 74.0)	47.0 (0.0, 61.8)	44.1 (15.4, 76.1)	81.4 (42.0, 89.2)	0.139
	cXCorr MD	9.4 (4.8, 10.8)	10.9 (8.1, 12.8)	10.9 (7.9, 14.2)	11.4 (8.8, 15.8)	12 (7.3, 18.9)	10.2 (7.1, 12.6)	0.370
SAX-M	n	25	32	56	70	78	14	
	TTP-SD	12.1 (1.9, 21.8)	15.4 (1.0, 22.2)	6.2 (1.2, 25.9)	1.3 (0.9, 6.8)	2.4 (1.0, 27.3)	2.2 (0.9, 8.6)	0.066
	MWD	34.0 (8.0, 53.0)	43.0 (5.5, 56.0)	21.0 (0.0, 66.0)	0.0 (0.0, 32.0)	14.0 (0.0, 56.0)	0.0 (0.0, 28.0)	0.093
	XCorr MD	11.0 (7.0, 14.0)	11.0 (9.0, 17.0)	12.0 (9.5, 16.0)	10.5 (7.0, 17.0)	10.5 (7.0, 21.0)	12.0 (10.0, 19.0)	0.785
	cTTP-SD	18.1 (2.8, 35.5)	21.3 (1.3, 28.4)	7.7 (1.4, 30.3)	1.4 (0.9, 8.5)	2.4 (1.1, 27.2)	2.4 (1.1, 8.9)	0.001
	cMWD	53.2 (12.9, 81.5)	59.6 (6.8, 77.5)	25.3 (0.0, 79.9)	0.0 (0.0, 40.0)	14.8 (0.0, 62.2)	0.0 (0.0, 26.7)	0.007
	cXCorr MD	16.2 (11, 22.9)	14.3 (11.2, 21.4)	13.5 (11.2, 19.7)	12.3 (7.3, 18.3)	10.9 (7.8, 20.6)	12.8 (9.8, 17.9)	0.141

HR = heart rate; TTP-SD = Time to peak strain standard deviation; MWD = maximal wall delay; XCorr MD = cross correlation mean segmental delay; cTTP-SD = heart-rate corrected time to peak strain standard deviation; cMWD = heart-rate corrected maximal wall delay ; cXCorr MD = heart-rate corrected cross correlation mean segmental delay.. All listed values are in milliseconds. Association assessed with Spearman correlation.

P2-124

miRNAs Associated with CTGF in a Murine Model with Banding and Debanding of the Ascending Aorta; Two-Dimensional Strain Echocardiography Study

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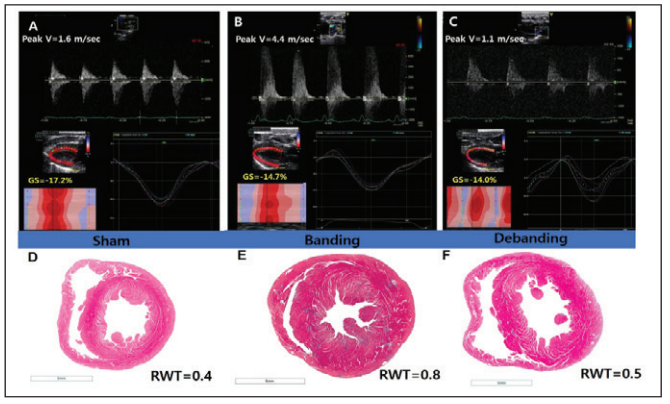
Background: The ascending aortic banding model can be used as an aortic stenosis model, and the debanding model can be used for reverse cardiac remodeling. Connective tissue growth factor(CTGF) is a profibrotic factor implicated in myocardial fibrosis of pressure overload mediated. In this study, we evaluated miRNAs targeting CTGF using pressure overload and reverse cardiac remodeling models. **Methods:** Minimally invasive ascending aortic banding was performed in 24 SD rats (male, 7 weeks old). Eight rats were assigned to the banding group and were sacrificed after 6 weeks. Eight rats were assigned to the debanding group, in which the aortic bands were removed after 28 days; these rats were sacrificed 2 weeks after band removal. We investigated the expression of CTGF, TGFβ1, and MMP2 using ELISA and examined miRNAs targeting CTGF using real-time qPCR in myocardial tissues of all subjects. Echocardiographic examinations were performed twice on all subjects, at baseline and six weeks after banding and 14 days after the debanding procedure. **Results:** Concentric hypertrophy resulted from the banding operation on the ascending aorta and was relieved after the debanding operation. CTGF expression was significantly higher in the banding group than that in the sham and debanding groups. The relative expression levels of miRNA-26b was higher in the debanding group than those in the banding group. The three-layered global circumferential strain and radial strain did not differ significantly among the groups. However, compared with the GLS in the sham group, the GLS in the banding and debanding groups was significantly increased. Compared with the GLS in the banding group, the GLS in the debanding group was not significantly improved(-18.7±1.0 vs. -15.2±2.3 vs. -15.5±2.7, p=0.008 for GLS), possibly because myocardial fibrosis was not significantly improved in the debanding group. **Conclusion:** The ascending aortic banding and subsequent debanding model can be used for reverse cardiac remodeling due to concentric LVH after a banding operation and the relief of concentricity after a debanding operation. CTGF, which plays an important role in myocardial fibrosis, decreased after the debanding operation. miRNA-26b could play roles in CTGF suppression in the reverse cardiac remodeling model.



P2-125

Right Ventricular Remodeling and Prognosis in Pulmonary Arterial Hypertension

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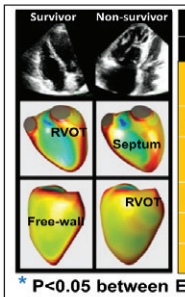
Background: Pulmonary arterial hypertension (PAH) causes significant changes in right ventricular (RV) shape, which may be associated with an adverse prognosis. No tools are currently available to assess RV shape. We hypothesized that surface analysis of the right ventricle using 3D echocardiography (3DE) with a parametric display of regional curvature indices would allow quantification of regional RV shape. Accordingly, we developed 3D analysis software to quantify regional RV shape and designed a study to determine whether alterations in shape are associated with mortality in PAH. **Methods:** 98 patients with PAH (54±15 years; 83% women) underwent transthoracic 3DE (Philips). 3D RV endocardial surfaces were obtained (TomTec) at end-diastole and end-systole (ED, ES) to measure RV volumes (EDV, ESV) and ejection fraction (EF) and analyzed to calculate mean curvature indices in 4 segments: inflow and outflow tracts (RVIT, RVOT), apex and body (divided into free-wall and septal regions). Mortality was determined using the Social Security Death Index. Differences in regional curvature indices between survivors and non-survivors were studied using independent t-test. Cox regression was used to determine if one or more curvature indices were associated with mortality. **Results:** 39 deaths occurred during follow-up (34±27mo). RV volumes were smaller and EF higher in survivors (EDV=213±72mL, ESV=129±64mL and EF=41±12% vs. 303±105mL, 205±88mL and 33±12%, respectively, in non-survivors; p<0.01). Inter-group comparisons showed that the septum was minimally convex, bulging into the left ventricle, similarly in both groups. The RVOT and RVIT were equally rounded in both groups. The body free-wall tended to be more convex in survivors without reaching significance. The apical free-wall, however, was significantly more pointed in survivors (Fig). Changes in RV shape between systole and diastole were more prominent in the survivor group, suggesting preservation of RV compliance (Table). Cox regression revealed that a decrease in apical free-wall curvature by 1 unit increases the odds of death 4-fold (HR=4.5[1.3,15.6], p=0.02). **Conclusions:** 3DE-based analysis of RV regional curvature provides prognostic information in patients with PAH: a rounded RV apex is associated with increased mortality.



Region	Survivors ED	Survivors ES	Non-survivors ED	Non-survivors ES
Apex-Free-wall	2.01 ± 0.29	2.00 ± 0.32	1.88 ± 0.24	1.84 ± 0.26
Apex-SEPT	0.85 ± 0.32	0.91 ± 0.39	0.84 ± 0.36	0.91 ± 0.34
Body-Free-wall	1.14 ± 0.09	1.08 ± 0.09*	1.11 ± 0.08	1.08 ± 0.08*
Body-SEPT	0.35 ± 0.17	0.39 ± 0.21*	0.40 ± 0.16	0.42 ± 0.18
RVIT	1.23 ± 0.13	1.17 ± 0.12*	1.26 ± 0.13	1.18 ± 0.23
RVOT	1.37 ± 0.16	1.32 ± 0.15*	1.35 ± 0.12	1.30 ± 0.11*

* P<0.05 between ED and ES

P2-126

Comparative Left Ventricular Systolic Motion Pattern of Patients with Left Bundle Branch Block Pattern

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Background: The electrical activation pattern in right ventricular apex pacing(RVAP), type B Wolff-Parkinson-White syndrome (WPW-B), premature ventricular complexes originating from right ventricular outflow tract (RVOT-PVCs) is similar to that of complete left bundle branch block (CLBBB). However, no data are available on the left ventricle (LV) motion pattern comparison in the patients with previously mentioned left bundle branch block (LBBB) pattern. **Methods:** 2D Speckle tracking was used to evaluate peak value and time to peak value of LV torsion, LV apex rotation, and LV base rotation in patients with RVAP (n=45), CLBBB with normal LV ejection fraction (n=28), WPW-B (n=38), RVOT-PVCs (n=42) and healthy controls (n=50). The time to peak value was expressed in a percentage relative to the R-R internal. Apical-basal rotation delay was calculated as the index of LV dyssynchrony. **Results:** Compared with the control group, LV motion pattern was altered in all of the patients, including the reduction of peak value of LV torsion, or apical/basal rotation, and dyssynchrony of LV apical-basal rotation (figure 1). Patients with RVAP and CLBBB had similar LV motion pattern, with reduced peak value of LV apex rotation and LV torsion. Patients with WPW-B demonstrated the opposite trend in the reduction of peak value of rotation, which is more dominant in basal layer. The most predominantly impairment in the peak value of LV torsion/rotation was found in patients with RVOT-PVCs (figure 2). Compared with the control group, apical-

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basal rotation delay was more prolonged in patients with CLBBB , followed by those with WPW-B, RVAP, and RVOT-PVCs, respectively. **Conclusions:** LV motion pattern was different among patients with LBBB pattern. CLBBB and RVAP demonstrated similar trends in the reduction of LV torsion/rotation, especially pronounced in the apical layer. While WPW-B showed more dominant reduction in the basal layer, and RVOT-PVCs in both layers. In addition, CLBBB showed the most pronounced LV apical-basal rotation dyssynchrony.

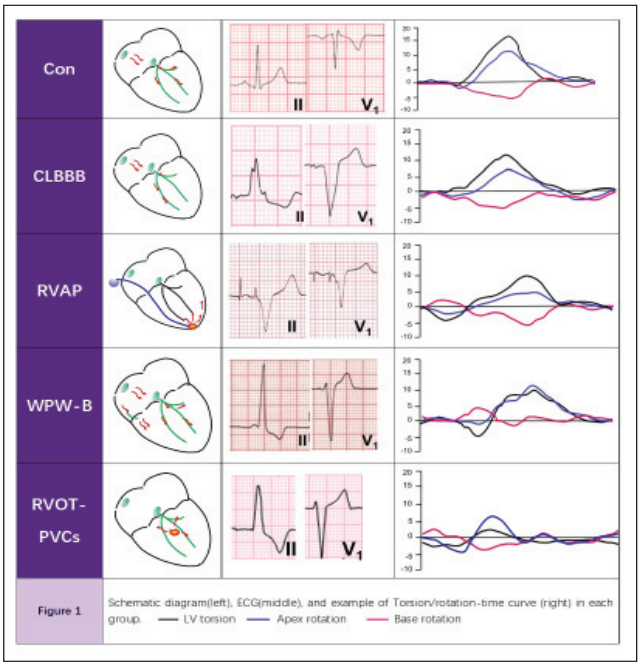

Figure 1 Schematic diagram(left), ECG(middle), and example of Torsion/rotation-time curve (right) in each group. — LV torsion — Apex rotation — Base rotation

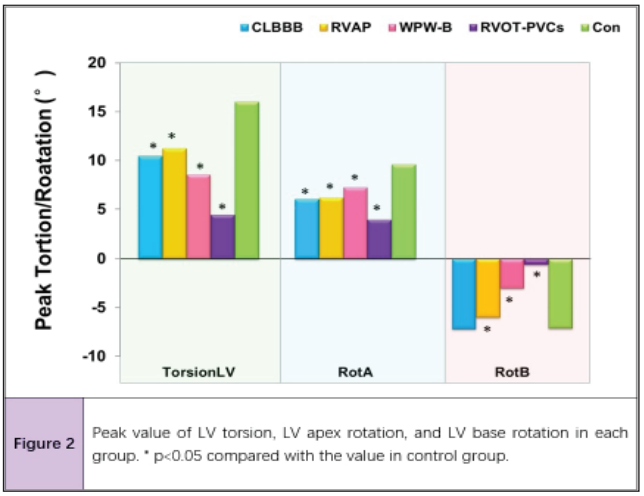

Figure 2 Peak value of LV torsion, LV apex rotation, and LV base rotation in each group. * p<0.05 compared with the value in control group.

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Right Ventricular Function and Beneficial Effects of Cardiac Rehabilitation in Patients with Chronic Heart Failure

Kenya Kusunose, Hiromitsu Seno, Hirotsugu Yamada, Susumu Nishio, Yuta Torii, Yukina Hirata, Yoshihito Saijo, Takayuki Ise, Koji Yamaguchi, Shusuke Yagi, Takeshi Soeki, Tetsuzo Wakatsuki, Masataka Sata. Tokushima University, Tokushima, Japan

Background: It has been recognized that a comprehensive cardiac rehabilitation (CR) program improves mortality in addition to functional cardiac capacity and symptoms in patients with chronic heart failure (CHF). On the other hand, the magnitude of the improvement in exercise capacity after CR differs among individuals. Recently, our laboratory developed preload stress echocardiography using leg positive pressure (LPP) to assess cardiac function during preload augmentation. We hypothesized that these more sensitive echocardiographic parameters, including right ventricular (RV) function during LPP, could be used to better predict the improvement in exercise capacity. The aim of this study was to assess the determinants of exercise capacity improvement after CR using preload stress echocardiography. **Methods:** We prospectively enrolled 41 CHF patients (age 62±11 years; 68% male) who had received optimized medical treatment in a CR program for 5 months. We performed preload echocardiographic studies during LPP. Cardiopulmonary exercise testing was performed before and after the CR program to assess exercise capacity. **Results:** Overall, the CR program significantly increased peak VO_2 from 14.5±4.6 mL/kg/min to 17.3±6.6 mL/kg/min (p <0.01). Significant improvement in peak VO_2 (>10%) after CR was observed in 24 patients, and peak VO_2 did not significantly improve in 17 patients. In a multivariable logistic regression model, the significant predictor of improvement in exercise capacity was RV strain during LPP (hazard ratio: 3.96 per 1 SD; p =0.01). A RV strain value of -16% during LPP had good sensitivity of 0.79 (95% CI 0.58-0.93) and specificity of 0.71 (95% CI 0.44-0.90) to identify patients with improvement in peak VO_2. **Conclusions:** RV strain during preload augmentation was a good predictor of improvement in VO_2 in CHF. Preload stress echocardiography is a useful method for identifying a subgroup that will have beneficial effects with CR.

P2-128

Applicability of Current Reference Values in Different Countries: Early Report from the World Alliance of Societies of Echocardiography (WASE) Normal Values Study

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Background: ASE chamber quantification guidelines provide recommendation for normal values for a variety of parameters. While used worldwide, these values were predominantly obtained from Caucasian North American and European populations. We hypothesize normal ranges presented in the Guidelines may not represent chamber size and function in other countries. Accordingly, the ASE in collaboration with its Alliance Partners is leading the World Alliance of Societies of Echocardiography (WASE) study to establish and compare normal echocardiographic values across races, ethnicities and countries worldwide. In this interim analysis, we report 2D echocardiography (2DE) left ventricular (LV) and atrial (LA) size and LV function of the countries that completed enrollment, and compared measurements with the reference values recommended by ASE 2015 guidelines. **Methods:** WASE is an on-going multinational, observational, cross-sectional study. Individuals free from known significant cardiac, lung and renal disease are being prospectively enrolled. China, Iran and South Korea completed enrolling 100 individuals evenly distributed among age groups and gender. The following parameters were acquired following the standard ASE protocol: LV ejection fraction, global longitudinal strain, end-diastolic volume and diameter, and LA volume. All measurements were analyzed (TOMTEC) at a Core laboratory following ASE Guidelines. Results are being compared with the ASE guidelines normal range values. **Results:** As of January, 2018, three countries have completed enrollment into the WASE study: China, Iran and South Korea, totalizing 300 individuals. The mean ± 2SD for each country, and their comparison against ASE guidelines normal range is shown in Figure. While the majority of patients fell within the Guidelines normal range for all parameters, some fell outside this range. Parameters with 5-10% and >10% of cases falling outside of the guidelines range are marked in the figure (* and ** respectively). **Conclusions:** Populations from China, Iran and South Korea in the WASE study have remarkable similarities to the normal ranges recommended in the ASE guidelines. However, small differences with the guidelines and between countries are noted, which need to be further investigated and reported with the completion of the study

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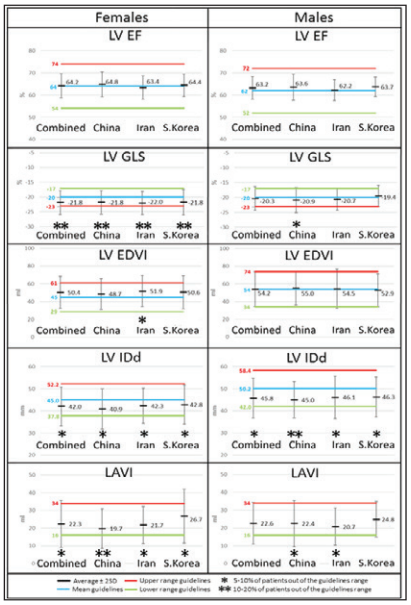

P2-129

Longitudinal Changes in Echocardiographic Measures of Ventricular Function after Fontan

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Background: While numerous indices have been developed in an attempt to quantify ventricular function in single ventricle patients after Fontan, there is little data on how these parameters change over time. **Methods:** A retrospective observational study of individuals who underwent Fontan operation at Children's Hospital of Philadelphia (CHOP) in 2006 was performed. To be eligible for inclusion, patients were required to have undergone a minimum of four echocardiograms at CHOP with a minimum of six months between each study. Patients were excluded if echocardiograms did not include apical 4-chamber imaging or Doppler assessments of the ventricular inflow and outflow. Measurements of fractional area change (FAC), tricuspid annular planar systolic excursion (TAPSE), and myocardial performance index (MPI) were made offline. A composite outcome of protein losing enteropathy (PLE) or death was created and change in function was compared between those who did and those who did not meet the outcome. **Results:** There were a total of 141 echocardiograms from 2006-2017 in 18 unique patients (67% male, 50% hypoplastic left heart syndrome). Three of the 18 patients met the composite outcome (2 PLE and one death). The aggregate mean values for all assessed parameters were worse than what would be expected for a healthy age-matched population without heart disease. All parameters worsened over time, however the changes were not statistically significant. (Table 1). There was no difference in the rate of change of ventricular function in those who met the composite endpoint versus those who did not. **Conclusion:** Although measures of ventricular function after Fontan operation were consistently different from what would be expected in a population without congenital heart disease, there were no significant change to these measures over a decade of follow-up. Similarly, no difference was noted between those who reached the composite endpoint of PLE or death relative to those who did not. This study demonstrated that failure of the Fontan circulation is multifactorial, and may occur without decline in systolic ventricular function. Future work that generates disease specific values for patients with Fontan operation would be useful to allow for a better assessment of ventricular performance in children with this unique physiology.

Table 1. Echocardiographic Measures of Ventricular Function Over Time

	Mean (Standard Deviation)	Rate of Change per Year since Fontan Operation (95% CI)	P-value	Effect of Composite Outcome on Rate of Change per Year since Fontan Operation (95% CI)	P-value
FAC (%)	34.1(6.3)	-0.087 (-0.0041, 0.0024)	0.22	0.35 (-0.012, 0.019)	0.66
TAPSE Z-score	-8.89 (1.83)	-0.052 (-0.14, 0.031)	0.61	0.12 (-0.12, 0.37)	0.32
MPI by Doppler of inflow	0.47 (0.15)	0.039 (-0.0035, 0.011)	0.3	-.0061 (-0.027, 0.015)	0.57
MPI by tissue Doppler	0.56 (0.143)	0.011 (-0.00089, 0.023)	0.07	0.028 (-0.0074, 0.063)	0.12

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Does Strain Imaging Reduce Variability in Echocardiographic Interpretation of Right Ventricular Systolic Function? A Cardiac Magnetic Resonance Imaging Correlation Study

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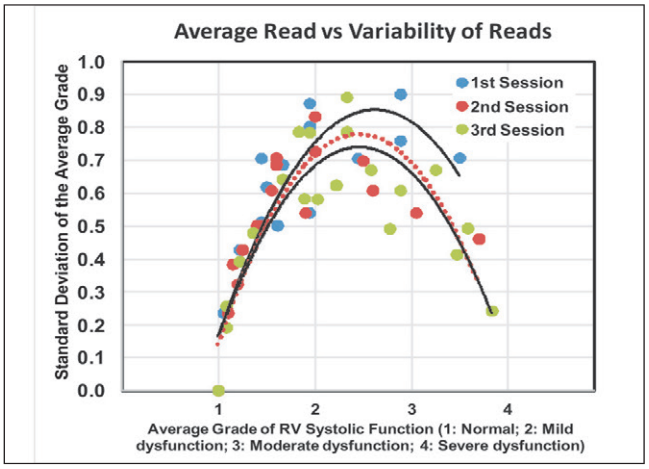
Background: It is unknown whether right ventricular (RV) global longitudinal (GLS) and free wall (FWS) strains reduce variability in echocardiographic interpretation of RV systolic function. **Methods:** Readers of varying expertise (staff, fellows, sonographers) assessed RV systolic function. In session one, 20 readers graded RV function of 19 cases, using conventional measures. After education, in session two, the same cases were re-assessed, with the addition of RV strains. In session three, 18 readers graded RV function of 20 new cases, with knowledge of RV strains. Computer simulations were performed to obtain 230 random teams. RV ejection fraction (RVEF) by cardiac magnetic resonance (CMR) was the reference standard. **Results:** The mean RVEFs by CMR were 46±11% (range: 21-60%; n = 19; first two sessions), and 40±11% (range: 21-59%; n = 20; third session). Correlation between RV GLS and CMR-derived RVEF was moderate: Spearman's rho: 0.70, n = 19, $p < 0.001$ (first two sessions); 0.55, n = 20, $p < 0.05$ (third session). RV strain parameters influenced echocardiographic interpretation, with a net reclassification index of 8.0±3.6% (p = 0.014). The variability between echocardiographic interpretation and CMR was minimal, when RVEF was either normal or severely reduced. The greatest variability in echocardiographic interpretation occurred, when RVEF was mild to moderately reduced ($p<0.0001$ for a quadratic component of a polynomial regression). Addition of strain parameters (second and third sessions) ameliorated, but did not eradicate, the variability in echocardiographic interpretation of RV systolic function for these cases. **Conclusion:** RV strain parameters showed moderate correlations with CMR-derived RVEF. The greatest variability in echocardiographic interpretation of RV systolic function occurred for cases with mild to moderately reduced RVEF by CMR. Addition of strain parameters ameliorated, but did not eradicate, the variability in echocardiographic interpretation of RV systolic function for these cases.



P2-131

Left Ventricular Wall Stress as a Reliable Predictor of Heart Failure Outcomes

Hassan Khan[1], Kalaimani Elango[1], Wassim Mosleh[1], Natdanai Punnanithinont[1], Tanvi Shah[1], Cale O'Keeffe[1], Sharma Kattel[1], Amit Jain[2], Umesh Sharma[1]. [1]University at Buffalo, Buffalo, NY; [2]The University of Tennessee Health Science Center, Memphis, TN

Background: Heart failure (HF) is associated with significant morbidity and mortality. The echocardiogram is the most commonly used imaging modality for the diagnosis and surveillance of HF. There are insufficient data for left ventricular wall stress (LVWS) as a reliable predictor of HF outcomes. In this study, we explore the relationship between LVWS and clinical outcomes of HF. **Methods:** We prospectively studied 103 patients (age≥18 yrs) who presented with clinical symptoms of HF. LVWS was calculated according to Laplace's equation from mid-cavity parasternal short axis view of a transthoracic Echocardiogram. The primary outcome was the composite endpoint of major adverse cardiovascular events (MACE), defined as cardiac mortality, recurrent myocardial infarction, revascularization, or stroke within 1-yr. Length of hospitalization (LOH) was also recorded. Analysis was done in the group as a whole and then in 4 subgroups such as HF with reduced ejection fraction (EF) ≤ 40% (HFrEF), HF with preserved ejection fraction > 40% (HFpEF), and presence or absence of history of coronary artery disease (CAD) irrespective of the type

of HF. A logistic regression model was used between ESWS and other factors such as age, history of diabetes, hypertension, atrial fibrillation, smoking, diuretic use, peak troponin and EF in the CAD subgroup to look for independent predictors of MACE. **Results:** There were no differences in both end-systolic wall stress (ESWS) and end-diastolic wall stress (EDWS) between MACE-positive and negative patients in the group as a whole and also in subgroups such as HFrEF, HFpEF, and non-CAD. However, in the CAD subgroup (n=55), ESWS was significantly higher in MACE-positive patients (118±91) compared to MACE-negative patients (66±29), whereas no difference was observed in EDWS. ESWS was an independent predictor of MACE with an odds ratio (OR)=1.027, p=0.02 and then ESWS and age were combined independent predictors of MACE with an OR=1.034, p=0.004 and OR=1.145, p=0.02, respectively. In addition, EDWS was positively correlated with LOH in the whole group (r=0.217, p<0.05) and in the subgroups such as HFrEF (r=0.351; p=0.03) and CAD (r=0.346, p=0.002) but not in the other two subgroups. EDWS was the single most independent predictor for LOH in the stepwise linear regression method with a t-score of 2.27 in HFrEF (p=0.03) and 2.37 in the CAD subgroup (p=0.02). **Conclusion:** LVWS could be a reliable prognostic tool in risk stratifying HF patients, especially with known CAD. Further studies in the larger clinical sample are needed to further understand the relationship of LVWS and clinical outcomes of HF.

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Echocardiographic Non-Response to Cardiac Resynchronization Therapy: Are They Real Non-Responders?

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Background: In patients with congestive heart failure (CHF) treated with cardiac resynchronization therapy (CRT) a reduction in left ventricular (LV) end-systolic volume (ESV) of ≥15% is a commonly used criterion of the response. Some patients have significant clinical improvement, decrease in NYHA functional class, good long-term survival, however they demonstrate suboptimal cardiac remodeling after CRT and they are identified as nonresponders. **The aim:** was to evaluate clinical, morphological, functional features and mortality in patients with suboptimal CRT response. **Materials and methods:** 109 patients (83.5% men) with NYHA functional class II-IV (mean age 54.6 ± 9.9 years). At baseline, 1, 3 months and each 6 months after implantation we evaluated clinical, electrocardiographic and echocardiographic parameters. According to the best decrease of LV ESV (mean follow-up period 34.8±16.7 months) patients were classified as non-progressors (n=18; decrease in LV ESV 0-14%), responders (n=41; decrease in LV ESV 15-29%) and super-responders (SR) (n=50; reduction in LV ESV ≥ 30%). **Results:** At baseline groups were matched for main clinical characteristics, the proportion of atrial fibrillation, width of the QRS complex, and the presence of left bundle-branch block (LBBB). Echocardiographic parameters didn't differ between groups. All groups demonstrated significant reverse remodeling of the LV, increase in LV ejection fraction (EF), increase in 6-minute walking distance. SR demonstrated the best improvement of clinical and functional parameters after CRT. However we found similar improvement in LV EF, LV ESV, NYHA functional class between responders and non-progressors and in dynamics mean values of these parameters were similar. The survival rates were 100% in SR, 80% in responders and 88.9% in non-progressors (Log-rank test p=0.004). When compared between groups survival rates in responders and non-progressors didn't differ significantly (Log-Rank test p=0.213). **Conclusion:** Patients with reduction in LV ESV 0-14% demonstrate similar improvement in clinical status and LV EF and similar survival rates as compared with those exhibiting reduction in LV ESV 15-30%. Non-progressors demonstrate similar survival as responders in long-term period. Taking into account the natural course of CHF we consider that functional stabilisation and absence of CHF progression in patients with LV ESV reduction 0-14% is a variant of good response and these patients should not be identified as non-responders. Thus the only use of percentage change in LV ESV to define CRT response is not always correct.

P2-133

3D Echocardiographic Semi-Automated Quantification of Left Ventricular Mass

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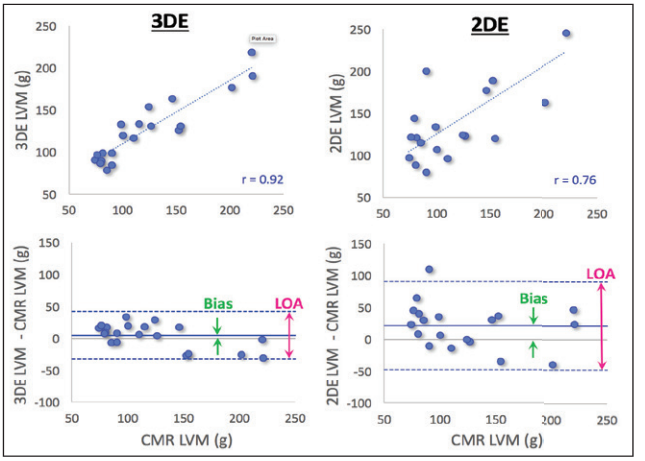
Background: Abnormal left ventricular (LV) mass is a predictor of adverse cardiovascular events. LV mass determined from 2D echocardiography (2DE) is limited by geometric assumptions of LV shape. Although 3D echocardiography (3DE) circumvents this limitation by allowing direct mass measurement without assumptions about LV shape and hypertrophy distribution, it is seldom used in clinical practice due to lengthy analysis time. A recently developed 3DE adaptive analytics algorithm (Philips Heart Model), allows automated determination of 3D LV mass. We hypothesized that this new automated algorithm would be more accurate than 2DE when compared to the reference standard of cardiac magnetic resonance (CMR). **Methods:** Twenty consecutive patients referred for a CMR were prospectively enrolled. Each patient underwent 2DE and 3DE (Philips EPIQ, X5-1 transducer) and CMR imaging (Philips 1.5T scanner) on the same day. LV mass was quantified at end-diastole using the 2DE area-length method, 3DE automated software, and by manual tracing of the endo- and epicardial borders at end-diastole in the CMR short-axis stack (Circle Cardiovascular Imaging). Linear regression and Bland-Altman analyses were used to compare 2DE and 3DE measurements of LV mass against the CMR reference. **Results:** There was no significant difference between LV mass measured from automated 3DE analysis and CMR, as reflected by high correlation (r=0.92), minimal bias (5g) and relatively narrow limits of agreement (LOA ±38g) (Fig, left). LV mass calculated from 2DE showed worse agreement with CMR, as reflected by a lower correlation (r=0.76), greater bias (22g) and wider LOA (±70g) (Fig, right). With the automated 3DE software, minor manual corrections of the endocardial borders were needed in 4/20 patients; however, correction of the epicardial borders was needed in the majority of cases (17/20). **Conclusions:** 3DE analysis of LV mass using the novel automated software was more accurate than conventional 2DE methodology, when compared to the reference standard of CMR. The use of semi-automated 3DE analysis to quantify LV mass should be incorporated into clinical practice.



P2-134

Impact of Left Ventricular Apical Function on Early Diastolic Suction During Exercise in Patients with Heart Failure

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Background: During exercise, early-diastolic pressure fall in the left ventricular (LV) apex augments LV suction, which is an important determinant of exercise capacity in healthy subjects. However, the contribution of LV apical function to LV suction and exercise capacity in heart failure patients has not been fully elucidated. We hypothesized that LV suction at peak exercise is closely linked to exercise capacity, and moreover, this LV suction could be generated by LV apical function in these patients. **Methods:** The cardiopulmonary exercise testing and exercise-stress echocardiography were performed in 47 heart failure patients (dilated cardiomyopathy 32%, ischemic heart disease 17%, hypertensive heart disease 17%, hypertrophic cardiomyopathy 11%, others 28%). Apical 4- and 2-chamber views and color M-mode Doppler image of LV inflow were obtained at baseline and peak exercise. LV ejection fraction (EF) was measured by the method of disks. LV apical endocardial area was measured at end diastole and end systole and apical fractional area change (ApFAC) was calculated. The early-diastolic intraventricular pressure difference (IVPD) from mitral annulus to the LV apex was determined using color M-mode Doppler to integrate the Euler equation as a parameter of LV suction. **Results:** During exercise, LV EF significantly increased (39±16% to 45±20%, P<0.01) whereas ApFAC did not (38±21% to 42±24%, NS). IVPD increased from 2.0±1.1 to 3.9±2.2 mmHg by the exercise (P<0.01). Although IVPD at rest did not correlate with peak oxygen uptake (VO_2), IVPD at peak exercise significantly correlated with peak VO_2 (R=0.70, P<0.01). At peak exercise, LV EF weakly correlated with IVPD (R=0.48, P<0.01). In contrast, ApFAC at peak exercise had a closer correlation with IVPD (R=0.67, P<0.01). **Conclusion:** Early-diastolic LV suction at peak exercise was closely associated with exercise capacity in heart failure patients. In addition, this LV suction could be influenced by LV apical function.

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Right Ventricular Strain Assessment After Tricuspid Valve Annuloplasty

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Background: Standard for treatment of severe tricuspid valve regurgitation is surgical repair with various types of annuloplasty rings. Traditionally, the echocardiographic assessment of tricuspid regurgitation pre and post ring repair has been performed with 2 dimensional measurements. However, right ventricular (RV) longitudinal strain may be reliable for RV assessment after annuloplasty. This study assesses the feasibility of measuring RV strain after tricuspid annuloplasty with three different types of rings. **Methods:** Twenty eight ovine subjects (61.3±6.2 kg) underwent sternotomy for a tricuspid valve annuloplasty ring. Of these rings, 10 animals received a Contour 3D rigid ring, 8 received a Duran Ancore® flexible ring, and 10 received a Tri-Ad Adams hybrid ring. Epicardial echocardiography was utilized to acquire images at baseline before surgery, after annuloplasty ring implantation and during inotropic stimulation with calcium. Images were analyzed on General Electric EchoPAC Image Vault Software. Post processed measurements included: Global Right Ventricular Peak Systolic Strain (GRVPSS), Right Ventricular Free Wall Peak Systolic Strain (RVFWPSS), Tricuspid Annular Plan Systolic Excursion (TAPSE), and Right Ventricular Fractional Area Change (RVFAC). The data was analyzed with a two-way repeated measure ANOVA and reported as least squared means ±SEM. **Results:** There was no difference in echocardiographic findings between the types of the ring implanted. Overall, GRVPSS value increased after implantation of the ring (-15.2±.6% vs. -10.4 ±.6%; p<.05; baseline vs. ring respectively) and decreased after calcium stimulation (-13.4±.7%; p<.05 vs. ring). There was an increase in RVFWPSS after ring placement (-19.1±1.1% vs. -15.9±1.5%; p<.05; baseline vs. ring) and no significant change with calcium (-14.0±1.2%; p>.05 vs. ring). TAPSE followed the same trend as RVFWPSS (1.3±.05cm vs. 1.0±.05cm vs. 1.1±6cm; p<.05; baseline vs. ring vs. calcium respectively). RVFAC decreased from baseline (50.6±1.4%) to ring implantation (44.5±1.4%; p<.05) and returned to baseline values after calcium (48±1.6%; p>.05 vs. baseline). **Conclusions:** It's feasible to perform global RV and RV free wall strain after tricuspid annuloplasty. Implantation of the annuloplasty ring increases GRVPSS value, independently of the type of ring used. Seeing that GRVPSS increases after calcium injection and RVFWPSS does not, it could be theorized that the RV septum compensates for decreased right ventricular free wall function. Follow-up studies are recommended.

P2-136

The Interaction of Left Ventricular Energy Loss by Vector Flow Mapping to Cardiac Deformation

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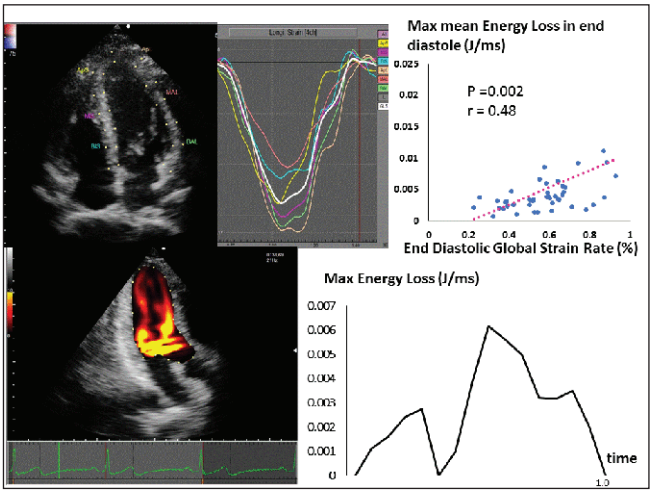
Background: Vector flow mapping (VFM) is a novel technique to evaluate cardiac flow dynamics noninvasively. Deformation by speckle tracking strain has emerged as a useful technique to assess left ventricular (LV) function. However, the relationship of LV efficiency reflected by VFM energy loss and global strain data are unclear. Our objective was to evaluate the relationship of global longitudinal strain (GLS) to LV energy loss by VFM. **Methods:** We studied 51 subjects: 39 normal controls and 12 patients with heart failure with reduced ejection fraction (HFrEF) (LVEF< 35%) by VFM and conventional echo methods (PROSOUND F75 Premier CV, Hitachi Corp.). Energy loss from vortex formation in the LV was analyzed from VFM color Doppler in the apical long axis view. Strain data were obtained from speckle tracking imaging from standard apical views. **Results:** VFM and GLS data were available in all subjects. Energy loss in mid systole was significantly correlated with stroke volume (SV), LV end diastolic volume index (LVEDVI) and global longitudinal strain (GLS) (p=0.01, <0.01, 0.005, respectively). Energy loss in early diastole was correlated with E wave velocity, LVEDVI and early diastole GLS rate (p=0.010, 0.049,0.037, respectively). Also, energy loss in end-diastole was correlated with A wave velocity, LA volume, and end-diastolic GLS rate (p=0.017, <0.01, 0.002, respectively). **Conclusions:** Energy loss by VFM is a new means to assess LV efficiency which may be combined with strain imaging. Calculations of energy loss in HFrEF patients and normal controls were related to flow parameters, chamber size, and cardiac function by strain imaging. The interaction of LV strain and energy loss by VFM has promise to refine noninvasive quantification of cardiac function.



P2-137

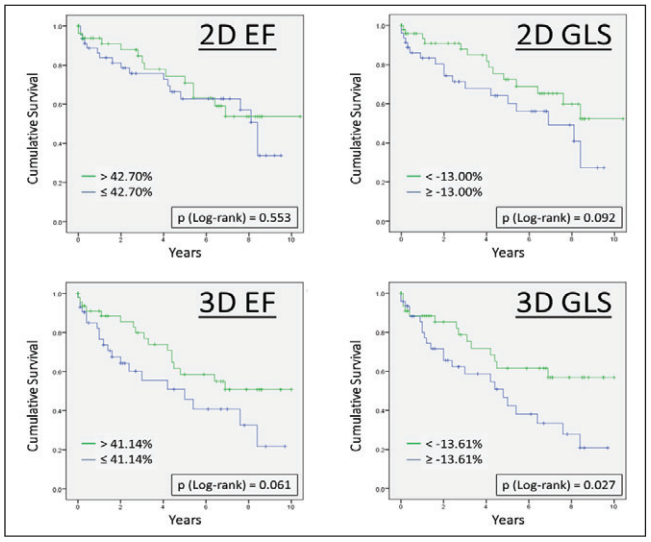
3D Global Longitudinal Strain Can Identify Patients with Mildly to Moderately Reduced Ejection Fraction at Higher Cardiovascular Risk

Diego Medvedofsky[1], Francesco Maffessanti[2], Lynn Weinert[1], David M. Tehrani[1], Akhil Narang[1], Karima Addetia[1], Anuj Mediratta[1], Stephanie Besser[1], Elad Maor[3], Amit R. Patel[1], Kirk T. Spencer[1], Victor Mor-Avi[1], Roberto M. Lang[1]. [1]University of Chicago, Chicago, IL; [2]Università della Svizzera Italiana, Lugano, Switzerland; [3]Sheba Medical Center, Tel Aviv, Israel

Background: Severely reduced left ventricular (LV) ejection fraction (EF) derived from 2D echocardiographic (2DE) images is known to be associated with increased mortality and is used to guide therapeutic choices. While ASE guidelines define this group of patients by a 2D LV EF cutoff of <30%, some patients with mildly to moderately reduced LV EF might also be at risk. Previous studies have shown that 2DE-derived global longitudinal strain (GLS) is more sensitive than 2D LV EF to detect abnormal LV function and accordingly may identify patients with mildly to moderately reduced LV EF who are at a similar cardiovascular (CV) risk level to those with severely reduced LV EF. Recently, 3D echocardiographic (3DE) measurements of EF and GLS were found to be more reliable and reproducible, because of their independence of imaging plane and geometric assumptions. We hypothesized that these 3DE parameters of LV function may also have better predictive value than the 2DE indices. We aimed at testing the ability of 2DE- and 3DE-derived EF and GLS to identify patients with mildly to moderately reduced LV EF who are at a higher CV risk. **Methods:** We retrospectively studied 103 inpatients (age 61±16) with 2DE-derived LV EF between 30-50% who underwent transthoracic echocardiography during 2006-2010 period, and had good quality 2DE and 3DE images. Mortality data through 2016 were collected. Both 2DE and 3DE images were analyzed to measure LV EF and GLS. Kaplan Meier survival curves were generated by splitting the study group into two subgroups using the median of each parameter as the cutoff. **Results:** Of the 103 patients, 32 (31%) died of CV related deaths. Kaplan Meier curves showed that 2D LV EF median (found at a cutoff of 42.7%) was unable to differentiate patients at higher CV mortality risk, 2D GLS (median: -13.0%) and 3D EF (median: 41.1%) showed only a trend, but 3D GLS (median: -13.5%) was the only parameter to identify patients at higher CV mortality risk (Figure). **Conclusions:** 3D GLS is able to identify patients with mildly to moderately reduced LV EF who are at higher CV mortality risk. Incorporation of 3D GLS into clinical decisions has the potential to improve survival in the subgroup of patients with mildly to moderately reduced LV EF who may benefit from therapeutic interventions that are not indicated according to the current guidelines.

Poster Session 2 (P2)

Monday, June 25, 2018



P2-138

The Takotsubo Meridian and Lateral Hinge-Point Angle: Novel Measurements to Define Myocardial Deformation in Takotsubo Cardiomyopathy

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Background: Takotsubo Cardiomyopathy (TC) is characterized by transient systolic dysfunction of the distal left ventricular (LV) segments in the absence of obstructive coronary artery disease (CAD). Differentiating TC from acute coronary syndrome (ACS) solely by echocardiography remains challenging and typically necessitates invasive coronary angiography (ICA). We hypothesized that patients with TC will have subtle echocardiographic differences that have not been described previously. **Methods:** This is a retrospective review of 52 patients diagnosed with TC. Quantitative echocardiographic measurements were performed by two independent researchers using Xcelera imaging software (Philips Medical Systems, Version R4.1L1-SP1). Novel measurements (Figure) were obtained using QLAB software (Version 10.3). Patients who underwent ICA to rule out obstructive CAD (Group 1) were compared to those without angiography but with echocardiographic evidence of apical ballooning (Group 2). All Group 2 patients had follow-up echocardiograms confirming resolution of LV wall motion abnormalities. **Results:** Contemporary echocardiographic measurements were similar between groups (Table). Of the novel measurements, the "lateral hinge-point angle" was greater among patients in Group 2 compared to those in Group 1 (108.5° vs. 95.7°, p=0.002). **Conclusion:** The angle defined by the Takotsubo meridian and lateral hinge-point is greater in patients who did not undergo ICA, suggesting that echocardiographers may unknowingly utilize this measurement when diagnosing TC. Novel measurements such as this may aid in the development of a completely non-invasive approach to differentiating TC from a left anterior descending artery infarction.

Table. Comparison of echocardiographic measurements between Group 1 and 2.

Variable	Baseline Measurements			% Change From Baseline		
	Group 1 (N=33)	Group 2 (N=19)	P-value*	Group 1 (N=33)	Group 2 (N=19)	P-value*
Heart rate (bpm)	88.2	93.7	0.386	-6.4%	-14.2%	0.483
Stroke volume (ml)	44.4	47.2	0.673	34.9%	52.6%	0.368
Cardiac output (L/min)	3.8	4.3	0.414	23.3%	18.5%	0.748
End-diastolic volume (ml)[1]	101.5	107.9	0.432	-14.3%	-16.5%	0.855
End-systolic volume (ml)[1]	54.8	61.4	0.252	-35.6%	-36.6%	0.937
Ejection fraction (ml)[1]	46.3	43.8	0.306	39.7%	38.2%	0.877
A4C longitudinal strain (%)[1]	-11.2	-10.5	0.421	83.0%	92.0%	0.703
A2C longitudinal strain (%)[1]	-9.8	-10.0	0.863	53.8%	107.9%	0.172
A3C longitudinal strain (%)[1]	-10.1	-8.7	0.187	112.4%	133.7%	0.560
Global longitudinal strain (%)[1]	-10.4	-9.7	0.446	88.4%	102.3%	0.550
SAX Strain - basal wall (%)[1]	-10.7	-10.7	0.767	74.9%	85.8%	0.649
SAX strain - mid-wall (%)[1]	-8.8	-8.8	0.244	76.7%	104.8%	0.448

*Continuous variables expressed as mean; P-value represents between-group differences

[1] Obtained using QLAB software; A4C = apical 4-chamber, A2C = apical 2-chamber, A3C = apical 3-chamber, SAX = short axis

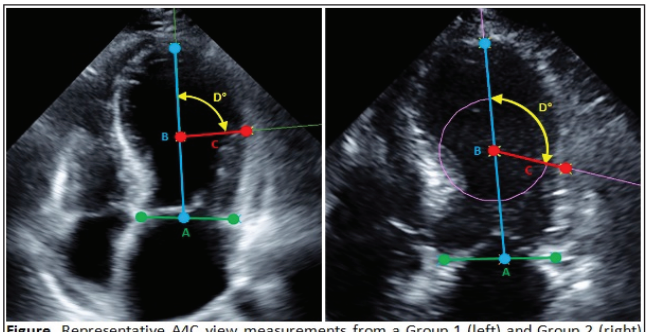

Figure. Representative A4C view measurements from a Group 1 (left) and Group 2 (right) patient. Using the ROI function of the QLAB software, a horizontal line was drawn from the septal to the lateral mitral annulus (A). A vertical line was then drawn from the LV apex to the midpoint of the annular plane (B). The **TC Meridian** (C) was drawn from the midpoint of B to the **lateral hinge-point**. The angle between B and C was termed the **lateral hinge-point angle** (D°). A4C = apical 4-chamber, ROI = region of interest, LV = left ventricular, TC = Takotsubo cardiomyopathy.

P2-139

QRS Duration Associate with the Reduction of Left Ventricular Twist in Isolated Complete Left Bundle-Branch Block with Preserved Ejection Fraction Using Two-Dimensional Speckle-Tracking Echocardiography

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Background: Left ventricular (LV) twist is a wringing motion of the heart, which was caused by the two counter-directional rotational movements of base and apex resulting from opposing arrangement of the LV subepicardial and subendocardial myocardial fibres. It has been revealed that LV twist plays an important role in pumping blood. Complete left bundle-branch block (cLBBB) may lead to LV dyssynchronous uncoordinated myocardial contraction. However, whether the LV dyssynchrony simultaneously affects LV twist by the changes of the sequence of LV rotation mechanics remains uncertain. The purpose of this study was to assess LV rotation and twist in isolated cLBBB patients with preserved LV eject fraction and explore the risk factors for the reduction of LV twist using two-dimensional speckle-tracking echocardiography (2D STE). **Methods:** Thirty-nine isolated cLBBB patients with preserved LV eject fraction and 33 healthy individuals matched by age and gender were studied. Apical rocking and septal flash were visually assessed by echocardiography. We assessed LV rotation and twist, global longitudinal systolic function (global strain) and synchronous (including intra-ventricle and inter-ventricle) using 2D STE. **Results:** There was no difference in baseline clinical characteristics between LBBB and control groups. LV mean apical rotation, basal rotation, and twist were decreased in isolated cLBBB patients than in controls (4.14° ± 2.36° vs. 8.12° ± 3.48°, −5.44° ± 3.67° vs. −8.17° ± 3.25°, 7.14° ± 3.60° vs. 13.69° ± 3.75° $p = 0.001$, all). Of the 39 isolated cLBBB patients, 16 (30.6 %) had a LV twist systolic dysfunction (LV twist < 5.3°). Multivariate logistic regression analysis identified QRS duration (odds ratio, 1.11; 95% confidence interval, 1.03-1.21; $p = 0.008$) as an independent risk factor predicting LV twist systolic dysfunction, after adjusting for the related factors, such as age, sex, apical rocking, septal flash, global strain, intra-ventricular synchronous and inter-ventricular synchronous. The LV twist correlated negatively with basal rotation in isolated cLBBB patients ($r = -0.39$, $p = 0.01$), but did not correlate with apical rotation ($r = 0.21$, $p = 0.21$). **Conclusions:** The cLBBB may induce the reduction of LV twist mainly by diminishing the LV basal rotation. And QRS duration independently associated with the reduction of LV twist in isolated cLBBB patients with preserved LV eject fraction.

P2-140

Left Atrial Strain is A New Marker of Neurocardiac Injury Predictive of Pulmonary Edema in Patients with Subarachnoid Hemorrhage

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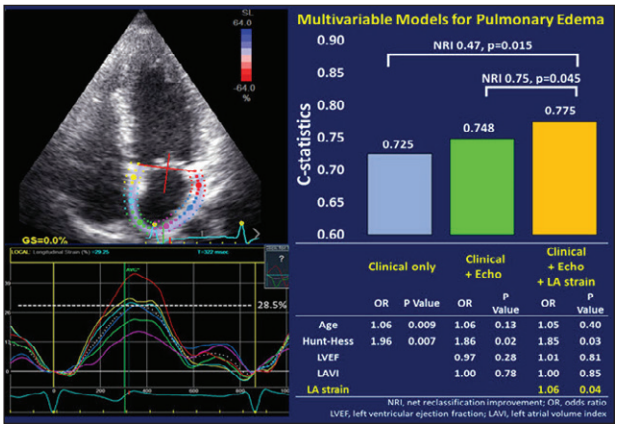
Background: Subarachnoid hemorrhage (SAH) has been reported to cause neurocardiac injury to a variable degree. However, effects of SAH on left atrial (LA) function are unknown. We tested the hypothesis that LA function by strain imaging is a marker for neurocardiac injury associated with pulmonary edema. **Methods:** We prospectively

studied 86 patients with acute SAH (52±11 years old, 72% female) with echocardiography in the acute phase (2.7±1.4 days from admission) (R01NR04221). LA function was assessed using speckle tracking strain imaging. Peak atrial longitudinal strain was obtained from apical 4- and 2- chamber views. Clinical severity of SAH was assessed by the Hunt-Hess grade. Troponin I and pulmonary edema by chest X-ray were assessed daily. **Results:** Patients were divided into 2 groups above and below median peak LA strain 36.2% [IQR 27.5 - 43.7%]. Patients in the lower peak LA strain group (≤ 36.2%) had significantly higher troponin I levels (0.26 [0.01 - 2.88] vs. 0.01 [0.01 - 0.13] ng/ml, p < 0.001) and slightly but significantly lower left ventricular ejection fractions (LVEF; 58±13% vs. 65±5%, p = 0.002). LA volume index was also higher in the lower LA strain group (LAVI; 47±15 vs. 40±16 ml/m^2). The incidence of pulmonary edema was significantly higher in patients with low peak LA strain (62.1% vs. 29.6%, p=0.018). Multivariable analysis showed lower peak LA strain was significantly associated with pulmonary edema (odds ratio 1.06 per 1% decrease, p = 0.043), even after adjusting for age, clinical severity of SAH, LVEF, and LAVI. Adding peak LA strain to a multivariable model improved the C-statistics and net reclassification improvement showed significant benefit of adding peak LA strain (p=0.045). **Conclusions:** In patients with acute SAH, lower peak LA strain was significantly associated with higher troponin levels and pulmonary edema. LA strain is a new marker of neuro-cardiac injury in SAH associated with clinical outcomes.



P2-141

Effect of Mechanical Unloading on Ventricular Systolic Function in Children Supported on Continuous Flow Left Ventricular Assist Device

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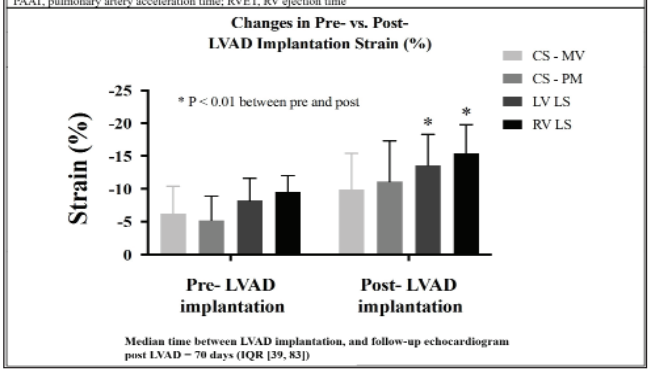
Background: Continuous-flow left ventricular assist device (LVAD) support as a bridge to heart transplant (HT) is a lifesaving therapy in end-stage heart failure patients. Emerging data in adults suggest that mechanical unloading of the left ventricle (LV) with LVAD can result in myocardial remodeling and improvement in cardiac function. Myocardial strain is a measure of tissue deformation, and speckle tracking echocardiography (STE) derived strain is a reliable non-invasive method to characterize right ventricle (RV) and LV systolic function in children. We evaluated RV and LV systolic function trends over 3-months using STE in children who underwent LVAD surgery. **Methods:** Eleven out of 34 patients who underwent LVAD placement had technically adequate STE imaging performed (HeartWare [8]; HeartMate II [3]; study period: 1/2013 to 02/2017). Echocardiograms were retrospectively reviewed before and within 3-months after LVAD implantation. **Results:** The diagnoses of the 11 patients [median age 10 years (IQR, 7.4, 15) and weight 25 kg (24, 70)] were congenital complete heart block (1), congenital heart disease (1), and dilated cardiomyopathy (9). The median time between LVAD implantation, and follow-up echo post LVAD was 70 days (IQR [39, 83]). The ejection fraction improved from 20% (14, 23) to 39% (35, 56) after LVAD (P < 0.001). LV longitudinal strain (LS) improved from -8.1% (-4.9, -12.1) to -13.7% (-10.9, -18.1) after LVAD (*P* = 0.006). There was a trend in LV circumferential strain improvement at both the mitral valve (base) and papillary muscle (mid-ventricle) levels (Table). RV fractional area change improved from 32% (26, 35) to 36% (35, 44) after LVAD (P<0.001). The pulmonary artery acceleration time improved from 88 (80, 92) to 110 (96, 114) after LVAD (P<0.001). RVLS improved from –9.3% (-7.7, -10.9) to -15.8% (-12.4, -18.0) after LVAD, (*P*= 0.003). On follow up, 6 patients underwent HT; LVAD was successfully explanted in 4 patients; and 1 patient remains on LVAD support (3.3 years). **Conclusions:** LVAD associated mechanical unloading improves RV and LV systolic function in children over time. Speckle-tracking echocardiography offers a complimentary noninvasive technique for monitoring right and left ventricular function in pediatric advanced heart failure patients on LVAD support.

Table: Echocardiographic data pre- and post- LVAD implantation (n=11 patients)

	Pre-LVAD Implantation	Post-LVAD Implantation	*P* value
LV systolic function			
LV EF (%)	20 (14, 23)	39 (35, 56),	< 0.001
LV LS (%)	-8.1 (-4.9, -12.1)	-13.7 (-10.9, -18.1)	0.006
LV CS (%) - MV	-4.8 (-3.4, -9.7)	-8.5 (-6.4, -13.1)	0.15
LV CS (%) - PM	-4.6 (-3.1, -5.4)	-10.5 (-6.3, -15.9)	0.06
RV systolic function			
RV FAC (%)	32 (26, 35)	36 (35, 44),	< 0.001
RV LS (%)	-9.3 (-7.7, -10.9)	-15.8 (-12.4,-18.0)	0.003
RV afterload			
PAAT (msec)	88 (80, 92)	110 (96, 114)	< 0.001
PAAT:RVET	0.42 (0.39, 0.45)	0.42 (0.41, 0.46)	0.4

Data presented as median (IQR);
Median age (years): 10 (7.4, 15); Median weight (kilograms): 25(24, 70)
Median time between LVAD implantation, and follow-up echocardiogram post LVAD = 70 days (IQR [39, 83])
LV, left ventricle; RV, right ventricle EF, ejection fraction
LS, longitudinal strain ; CS, circumferential strain
MV, mitral valve (base); PM, papillary muscle (mid-ventricular)
FAC, fractional area of change
PAAT, pulmonary artery acceleration time; RVET, RV ejection time



P2-142

Variability in 2D Echo Assessment of LV Size and Functional Indices in an Academic Pediatric Echo Lab

David E. Saudek, Sara Shreve, Jessica Stelter, Evelyn Kuhn, Peter Frommelt. Children's Hospital of Wisconsin, Milwaukee, WI

Background: Variation in 2D echo measurements between providers may impact clinical decision-making but has not been well studied in pediatric patients. **Methods:** All sonographers, cardiology fellows, and attending echocardiographers employed in a pediatric echo lab made blinded measures of the aortic root and left heart chambers from parasternal long axis, short axis, and apical images. Measures were made on high quality de-identified 2-D images from a single normal study (T1). A teaching session then reviewed measurement techniques in an effort to decrease variation. Providers then blindly repeated measures from the same study (T2). ANOVA assessed differences in measures between provider types. Paired t-test was used to assess changes in measures from T1 to T2. **Results:** Measures were performed by 12 sonographers, 10 fellows, and 11 attending physicians. Measurements yielded normal z-scores in 98.2%. Coefficient of variation was highest for calculated volumes and LV wall thickness (>14%) and did not decrease at T2 (Table 1). Variation was lowest for aortic root measurements (2.8-5.3%). Fractional shortening (FS) ≤27% was calculated in 15% and ejection fraction (EF) ≤55% in 27%. At T2, FS was abnormal in 25% and EF abnormal in 17%. Measurements differed by provider type only for LV diastolic volume at T2 (p=0.01). Significant changes from T1 to T2 include increased ascending aorta (1.98 v 1.99 cm, p= 0.02) and LVIDs (2.40 v 2.45 cm, p= 0.02) in aggregate measurement. Sonographers measured decreased LV systolic volume (15.97 v 14.48 ml, p=0.03) and increased ascending aorta (1.97 v 1.99 cm, p<0.01) and EF (60% v 64%, p=0.02). **Conclusion:** 2D echo measures of chamber volumes and LV wall thickness in a single normal study with optimal imaging show significant variation between providers in an experienced pediatric lab. Review of proper technique in making measurements did not decrease variation. This study highlights the subjective nature of these measures raising questions about their reliability in clinical practice.

Poster Session 2 (P2)

Monday, June 25, 2018

TABLE 1

Measurement	Time 1 Mean (SD)	Time 1 Coefficient of variation	Time 1 ANOVA (p value)	Time 2 Mean (SD)	Time 2 Coefficient of variation	Time 2 ANOVA (p value)
Aortic Annulus (cm)	1.45 (0.05)	3.3%	0.05	1.46 (0.05)	3.3%	0.26
Aortic Sinus (cm)	1.98 (0.05)	2.8%	0.38	1.99 (0.03)	1.6%	0.63
Aortic ST Junction (cm)	1.55 (0.07)	4.7%	0.71	1.56 (0.09)	5.8%	0.15
Ascending Aorta (cm)	1.64 (0.09)	5.3%	0.14	1.68 (0.06)	3.5%	0.16
Ventricular Septal thickness (cm)	0.51 (0.07)	14.5%	0.89	0.48 (0.07)	15.6%	0.65
LVIDd (cm)	3.45 (0.19)	5.6%	0.08	3.48 (0.13)	3.7%	0.63
LVIDs (cm)	2.41 (0.13)	5.2%	0.25	2.45 (0.09)	3.7%	0.26
LV Posterior Wall (cm)	0.48 (0.13)	26.3%	0.26	0.44 (0.08)	18.8%	0.27
Fractional Shortening	0.30 (0.03)	9.9%	0.57	0.30 (0.03)	10.7%	0.80
LV Diastolic Volume (ml)	35.52 (6.90)	19.4%	0.12	35.93 (7.86)	21.9%	**0.01**
LV Syst Volume A4C (ml)	14.17 (2.60)	18.4%	0.16	13.61 (2.48)	18.2%	0.35
EF	0.60 (0.05)	9.2%	0.67	0.62 (0.06)	9.5%	0.13
Left Atrial Volume Index (ml/m2)	31.09 (5.45)	17.5%	0.06	29.43 (7.74)	26.3%	0.78

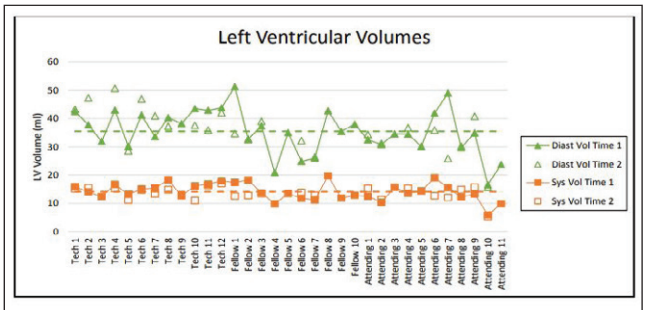


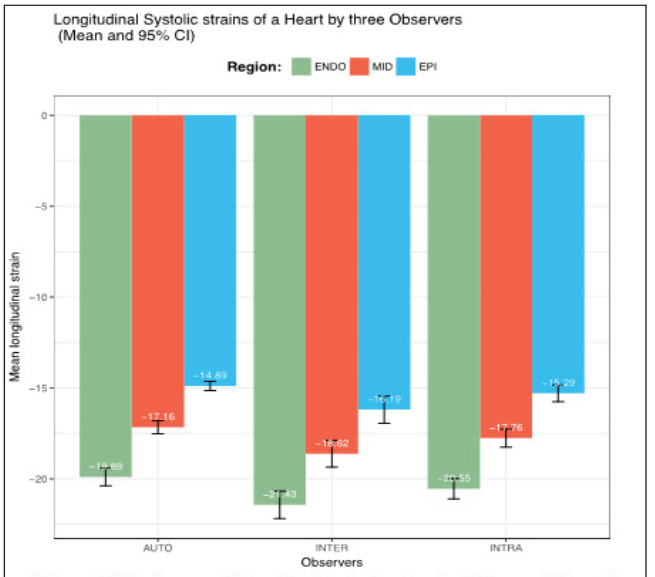
Figure 1: Ventricular volumes are displayed for each provider. Dashed lines reflect mean diastolic and mean systolic volumes.

P2-143

Inter- and Intra-Observer Variability in Layer-Specific Strain Analysis: A Feasibility Study

Angela B. Malone[1], Adnan Kassier[2], Nabin K. Shrestha[1], Rachel C. Phillion[1], Lou A. Mitchell[1], Rhonda A. Coleman[1], Lenora L. Eberhart[1], Stefan M. Jovinge[1], David E. Langholz[1]. [1]Spectrum Health Heart and Vascular Institute, Grand Rapids, MI; [2]Spectrum Health/ Michigan State University, Grand Rapids, MI

Background: Global longitudinal strain (GLS) by speckle tracking echocardiography (STE) is utilized in many laboratories for quantification of left ventricular function. Variability of STE in tracking GLS between observers is a challenge, although multiple studies report inter- and intra-observer reproducibility measurements of GLS to be superior or at least comparable to those of ejection fraction. Algorithms exist to measure layer-specific strain, separating the fibers into endocardial (ENDO), mid-myocardial (MID) and epicardial (EPI) layers. A multilayer analysis of myocardial deformation enables discrimination of transmural differences owing to several disease processes including hypertension, myocardial ischemia or necrosis. This study determined inter- and intra-observer variability in measuring layer-specific strain, with a hypothesis that inter-observer variability would be greater than intra-observer variability. **Methods:** Ten sonographers experienced in performing GLS comprised the INTER group. Each performed layer-specific strain analysis in General Electric EchoPAC 201 on the same images. The INTRA group was one sonographer performing the measurements 10 times, manually placing points and adjusting the tracings. The AUTO group was the same sonographer placing points and the computer setting the tracings 10 times. Sonographers performed the analysis according to an instructional document. Data was analyzed using R software. Bartlett's test was used to test whether there is actual variability between sonographers in the measurements of different layer-specific segments. **Results:** AUTO variability was smaller than INTRA and INTER in all regions. However, it was only statistically significantly smaller than INTER variability in EPI and MID regions. The variability of INTRA seems smaller than that of INTER, but was not statistically significant. **Conclusion:** This small pilot study failed to demonstrate a statistically significant difference between INTER and INTRA groups. It may be feasible to perform layered GLS by a group of well-trained observers rather than one dedicated observer. In addition, given the contemporary analysis tools on commercially available echo systems, sonographer experience seems to be less of a variable in standardization of GLS data acquisition.



Mean±SD of mean* longitudinal strains by Site and Location (mean*= avg. of APLAX, A4 and A2 for each observation)

Method	ENDO	MID	EPI
AUTO	-19.89 ± 0.68	-17.16 ± 0.51	-14.89 ± 0.36
INTER	-21.43 ± 1.05	-18.62 ± 1.03	-16.19 ± 1.04
INTRA	-20.55 ± 0.78	-17.76 ± 0.7	-15.29 ± 0.64

Table of *p*-values for comparing variance between Methods (Bartlett's test for Equality of Variance)

Region	AUTO vs INTER	AUTO vs INTRA	INTRA vs INTER
ENDO	0.11	0.36	0.19
MID	0.02	0.18	0.13
EPI	<0.01	0.05	0.08
OVERALL	0.27	0.36	0.4

P2-144

Acute Effect of Multipoint Left Ventricular Pacing in Patients Receiving Cardiac Resynchronization Therapy

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Objectives: Multipoint pacing (MPP), as a novel means of cardiac resynchronization therapy (CRT), is supposed to improve left ventricle (LV) function by capturing a larger LV tissue area, resulting in uniform wave front propagation throughout the ventricles. The aim of this study was to evaluate the acute effect of MPP on LV hemodynamics and dyssynchrony, in comparison with conventional CRT. **Methods:** Ten patients with non-ischemic dilated cardiomyopathy (mean age 61.7±9.6 years; NYHA III; QRS duration 164.8±22.5 ms; LV ejection fraction 25%±6%) were include. After the implantation procedure, an acute pacing protocol was performed, including routine bipolar ventricular pacing (Biv, RV+ LV distal site pacing), selective single-point ventricular pacing (Qiv, RV+LV latest excitation site pacing) and MPP (RV +LV earliest and latest excitation sites pacing) with a quadripolar LV lead (Quartet, St.Jude Medical, Inc). There was a 10-min washing interval between each pacing modality. Electrocardiography and echocardiography was performed at baseline and three pacing interventions. The evaluation index includes QRS duration, LV end diastolic volume (LVEDV), end systolic volume (LVESV) and ejection fraction (LVEF), global longitudinal strain (GLS) and standard deviation of time to peak longitudinal strain (PSD) of 16 segments using Triplane speckle tracking imaging, interventricular mechanical delay (IVMD) and Yu index. **Results:** Compared with baseline, a significant reduction of LVESV and IVMD, and improvement of LVEF can be observed in all three pacing modalities ($P < 0.05$). There was a gradually increasing tendency in LVEF (baseline vs. Biv vs. Qiv vs. MPP, 24.7±5.9 vs. 30.7±10.3 vs. 31.8±11.0 vs. 33.8±10.9 %) and GLS (baseline vs. Biv vs. Qiv vs. MPP, -5.9±2.5 vs. -6.0±2.6 vs. -6.7±3.1 vs. -7.0±3.2 %). A similar decreasing tendency was also revealed in LVESV (baseline vs. Biv vs. Qiv vs. MPP, 215.4±133.4 vs. 192.0±143.0 vs. 173.8±137.4 vs. 171.3±145.8 mL), PSD (baseline vs. Biv vs. Qiv vs. MPP, 122.6±37.1 vs. 105.0±28.4 vs. 82.3±19.2 vs. 86.8±35.2 ms) and QRS width (baseline vs. Biv vs. Qiv vs. MPP, 164.8±22.5 vs. 156.9±18.9 vs. 157.3±18.9 vs. 154.7±25.1 ms). Although they did not reach statistical significance among the three pacing modalities. **Conclusions:** These preliminary results suggest that all three pacing modalities resulted in significant improvement of LV myocardial contractility and dyssynchrony. MPP tends to be superior

to Biv and Qiv in improving acute hemodynamic response. More studies with large samples and longer follow up are needed for further clarification.

P2-145

Acute Echocardiographic and Biomarker Changes in Recreational Half-Marathon Runners

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Background: Although the acute changes in cardiac function on echocardiography and acute cardiac injury by biomarker assessment are well characterized in elite ultra-endurance white and Afro-Caribbean athletes, a similar information for recreational middle aged, South East Asian runners during a half marathon is not adequately available. The South East Asian subjects are also known to have premature coronary atherosclerosis and higher prevalence of metabolic syndrome. **Methods:** Transthoracic echocardiography and serum N-terminal pro-brain natriuretic peptide (NT-proBNP) level estimation was performed 48 hour prior to, immediately after (within 2 hours) and 48 hours after the completion of half marathon in 24 male recreational marathon runners [age 40.57 ±7.36 years]. 2D Echocardiography, Doppler and Speckle tracking Echocardiography were used to characterize the changes in myocardial mechanics. **Results:** The salient findings are summarized in the table. There was a significant increase in Right ventricular (RV) free wall global longitudinal strain (GLS) immediate post marathon which persisted for 48 hrs. This was associated with significant increase in NT-proBNP immediate post Marathon which persisted for 48 hours. Although, there was no change in left ventricular ejection fraction LVEF, LVGLS or LV global radial strain (GRS), there was significant fall in LV global circumferential strain (GCS) immediate post-marathon with recovery to baseline by 48 hours. Interestingly, there was significant increase in LV end systolic dimension and left atrial (LA) volume immediate post Marathon which persisted for 48 hours. **Conclusion:** South East Asian recreational half Marathon runners, immediately post marathon, show increase in RV free wall GLS, reduction in LV GCS and increase in LV end systolic dimension and LA volume with concomitant rise in BNP. These changes persisted for 48-hour post Marathon except for LV-GCS.

Parameter	Pre-marathon	Immediate Post marathon(2hrs)	Post-marathon (48 hrs)	P-value
Heart rate (beats /minute)	72.96±7.35	75.42±8.55	74.46±6.53	0.425
Left ventricular end diastolic dimension (cm)	4.32±0.52	4.43±0.52	4.28±0.65	0.562
Left ventricular end systolic dimension (cm)	2.91±0.49	3.18±0.53	3.71±1.20	**0.015**
Left ventricular end-diastolic volume (ml)	88.75±20.19	87.29±20.88	87.88±25.9	0.957
N-terminal pro-brain natriuretic peptide (pg/ml)	34.75±26.25	58.92±26.97	40.04±29.15	**0.009**
Left atrial volume (ml)	30.38±10.34	49.04±16.01	43.21±14.54	**<0.0001**
Left ventricular end-diastolic volume (ml)	88.75±20.19	87.29±20.88	87.88±25.9	0.957
Left ventricular ejection fraction (%)	57.92±6.62	56.25±9.43	55.92±6.5	0.453
Mitral inflow early diastolic velocity (m/s) (E)	0.88±0.22	0.85±0.13	0.79±0.17	0.151
Lateral mitral annular early diastolic velocity (m/s) (e')	0.16±0.13	0.11±0.02	0.11±0.02	0.091
Lateral mitral annular early diastolic velocity (m/s) (e')	0.13±0.02	0.12±0.03	0.13±0.02	0.601
Mitral E/e'	6.60+1.78	7.40+2.17	6.67+1.66	0.199
Left ventricular global longitudinal strain (%)	-17.83±3.16	-17.67±3.75	-16.75±3.12	0.381
Left ventricular global circumferential strain (%)	-18.05±4.01	-16.36±2.55	-18.42±1.82	**0.05**
Left ventricular global radial strain (%)	34.31±3.11	34.57±2.79	33.88±3.17	0.305
TAPSE (cm)	2.13±0.3	2.13±0.33	2.28±0.25	0.145
Right ventricular S' (m/s)	0.12±0.02	0.12±0.02	0.13±0.02	**0.05**
Right ventricular global longitudinal strain (%)	22.63±4.22	25.21±4.85	26.75±2.77	**0.002**

P2-146

Diastolic Function is Independently Associated with Aortic Calcification in Patients with Preserved Ejection Fraction

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Background: Aortic calcification is an independent predictor of cardiovascular morbidity AND mortality, irrespective of traditional coronary risk factors. However, the mechanism underlying the relationship between aortic calcification and cardiovascular events remains unknown. We aimed to determine whether there are any independent associations between the degree of aortic calcification AND clinical factors or left ventricular (LV) function. **Methods:** We retrospectively reviewed the records of 543 patients (median age, 74 years; 327 males) who underwent clinically-indicated computed tomography AND echocardiography at our hospital between October 2012 and July 2014. The calcification volume at the aortic wall was assessed as any area >1 mm^3 with attenuation ≥200 Hounsfield units. **Results:** The median aortic calcification volume was 10.9 mL (25^{th} and 75^{th} percentile, 2.9, 22.2). On univariable linear regression, aortic calcification volume was associated with age, hypertension, diabetes mellitus, ischemic heart disease, hemodialysis, AND smoking. Regarding blood pressure (BP), pulse pressure and systolic BP were associated with aortic calcification, while diastolic BP was not. Regarding aortic stiffness, calcification was associated with arterial elastance AND total arterial compliance. Regarding cardiac function, significant association was found for diastolic functional parameters (E/A ratio, deceleration time, e', E/e', ANDAND left atrial volume index [LAVI]) but not for ejection fraction. On multivariable linear regression, age, diabetes mellitus, ischemic heart disease, smoking, e', AND LAVI remained independent predictors of aortic calcification. **Conclusions:** LV diastolic function was independently associated with aortic calcification volume, suggesting that aortic calcification may result in an adverse cardiovascular prognosis through deteriorated LV diastolic function.

Table: Univariable and multivariable linear regression analyses for associations with aortic calcification

	Univariable analysis			Multivariable analysis model(R^2=0.42)		
	β	(95%CI)	p value	β	(95%CI)	p value
Age, years	0.053	(0.046 – 0.059)	<0.001	0.049	(0.042 – 0.056)	<0.001
Male	0.15	(-0.065 – 0.361)	0.17	-	-	-
HT	0.53	(0.326 – 0.736)	<0.001	-	-	-
DM	0.36	(0.128 – 0.598)	0.002	0.24	(0.049 – 0.423)	0.014
IHD	0.59	(0.317 – 0.857)	<0.001	0.39	(0.166 – 0.604)	0.001
Hemodialysis	0.51	(0.172 – 0.838)	0.003	-	-	-
Smoke	0.24	(0.028 – 0.446)	0.026	0.46	(0.292 – 0.624)	<0.001
SBP, mmHg	0.006	(-0.013 – 0.003)	0.20	-	-	-
DBP, mmHg	-0.006	(-0.013 – 0.002)	0.13	-	-	-
PP, mmHg	0.017	(0.011 – 0.024)	<0.001	-	-	-
Ea, mmHg/ml	0.12	(0.012 – 0.223)	0.03	-	-	-
LVEF, %	0.00	(-0.015 – 0.015)	0.99	-	-	-
E/A ratio	-0.88	(1.200 – -0.563)	<0.001	-	-	-
e', cm/sec	-0.21	(-0.251 – -0.164)	<0.001	-0.059	(-0.102 – -0.016)	0.007
E/e' ratio	0.077	(0.056 – 0.098)	<0.001	-	-	-
LAVI, ml/m^2	0.028	(0.020 – 0.036)	<0.001	0.011	(0.007 – 0.015)	<0.001
LVMI, g/m^2	0.007	(0.003 – 0.011)	<0.001	-	-	-

Abbreviations: HT, hypertension; DM, diabetes mellitus; IHD, ischemic heart disease; SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; Ea, arterial compliance; LVEF, left ventricular ejection fraction; LAVI, left atrial volume index

P2-147

Heart Failure with Mid-Range Ejection Fraction: Are Left Ventricular or Left Atrial Strain Associated with Increased Mortality?

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Background: Patients with heart failure with mid-range ejection fraction (HFmEF), defined as those with left ventricular ejection fraction (LVEF) between 40 and 50% and clinical heart failure, are a category recently introduced by the European Society of Cardiology. However, risk stratification of patients with HFmEF is not well established. Left ventricular (LV) and left atrial (LA) global longitudinal strain (GLS) are known to be useful in risk stratifying patients with heart failure and reduced LVEF. Accordingly, we hypothesized that these parameters may also be useful in the HFmEF population. This study aimed at evaluating the association between LV and LA GLS with all-cause mortality in HFmEF patients. **Methods:** We retrospectively studied transthoracic echocardiograms (TTEs) of 944 patients with LVEF 40-50%. Chart review was performed to determine if these patients met the diagnosis of HFmrEF, determined by history of clinical heart failure or abnormal NT-proBNP level (>300 pg/mL). Exclusion criteria included atrial fibrillation, severe arrhythmia, or a paced rhythm, moderate or severe valve disease, prosthetic valves, greater than mild pericardial effusion, and patients with cancer on chemotherapy. Patients who fit the criteria were then divided into an all-cause mortality group and a surviving group, based on survival during the following 5-year period. Propensity matching based on age, body mass index (BMI), LVEF, and LA volume index (LAVI) was able to match 21 patients in the mortality group with survivors. LV GLS and LA GLS were calculated using Q Lab (Philips). Matched analysis was performed using paired T-tests. **Results:** There was no significant difference in LV GLS between the two groups (-13.0% ± 2.7% versus -13.3 ± 3.2%, p=0.38). There were also no significant inter-group differences in LA GLS (20.9 ± 10.2 versus 16.5 ± 8.9, p=0.17). **Conclusions:** HFmrEF is a group of patients that is challenging to risk stratify. LV GLS and LA GLS were not found to be significantly associated with 5-year all-cause mortality in patients with HFmrEF. Further investigations are needed to find which patients with HFmrEF are at increased risk.

Poster Session 2 (P2)

Monday, June 25, 2018

P2-148

Postnatal Evolution of Left Ventricular Rotational Mechanics in Preterm Infants

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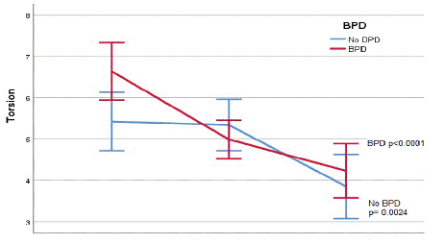
Background: Premature birth impacts myocardial development and maturation of the left ventricle (LV). The aims of this study were to characterize maturational changes in LV rotational mechanics and establish reference values for LV twist and torsion in preterm infants through 1 year corrected age (CA). **Methods:** 118 preterm infants (<29 weeks, <1500 grams at birth) were prospectively enrolled at birth and followed to 1 year CA through the Prematurity and Respiratory Outcomes Program (U01 HL10179). Utilizing two dimensional speckle tracking echocardiography at 32 and 36 weeks postmenstrual age (PMA) and 1 year CA, LV basal rotation, apical rotation, twist and torsion (twist normalized against LV length) were acquired in the parasternal short axis view at appropriate levels and analyzed offline with customized software (GE EchoPac). A mixed random effects model with repeated measures analysis, controlling for gestational age and bronchopulmonary dysplasia (BPD), was used to determine change in LV torsion over time. Subgroup analysis was performed to determine if LV rotational mechanics change over time in infants with and without BPD. **Results:** LV torsion significantly decreases ($p<0.001$) from 32 weeks PMA to 1 year CA (Table). The initial counterclockwise rotation and subsequent clockwise basal rotation are prominently present from early age and increase significantly ($p<0.001$) over time. In comparison, the initial clockwise apical rotation increases ($p<0.05$) but the counterclockwise apical rotation does not change over time. Twist remains unchanged ($p=0.2$) while the torsion significantly decreases. Both infants with and without BPD exhibit similar changes in LV torsion over time (Figure). **Conclusion:** Preterm infants exhibit changes in counterclockwise and clockwise LV rotation with decreasing torsion through 1 year CA. This study establishes reference values of LV rotational mechanics in preterm infants and describes postnatal maturational changes that may be clinically applicable for evaluation of LV function.

Table: Maturational patterns of rotational mechanics in preterm infants

	32 weeks PMA n=114	36 weeks PMA n=118	1 year CA n= 65	p-value
Basal Rotation (°)				
Initial counterclockwise(+)	2.22 ± 1.74[A]	2.35 ± 1.62[A]	3.93 ± 3.72[B]	0.0016
Clockwise (-)	-7.31 ± 4.08[A]	-7.19 ± 3.75[A]	-9.51 ± 4.76[B]	0.0014
Apical Rotation (°)				
Initial Clockwise (-)	-0.92 ± 1.78[A]	-1.49 ± 1.47[B]	-1.48 ± 2.28[A,B]	0.0158
Counterclockwise (+)	9.12 ± 4.98	9.80 ± 3.96	8.82 ± 5.15	0.2045
Twist (°)	14.07 ± 6.16	14.57 ± 5.58	15.7 ± 7.80	0.2137
Twist Trough (°)	-0.63 ± 0.92[A]	-0.83 ± 1.08[A]	-3.32 ± 3.18[B]	<.0001
Length (cm)	2.31 ± 0.24[A]	2.85 ± 0.27[B]	3.86 ± 0.23[C]	<.0001
Torsion (°/cm)	6.14 ± 2.73[A]	5.13 ± 2.04[B]	4.08 ± 2.02[C]	<.0001

Footnote: Postmenstrual age (PMA), corrected age (CA). A mixed model with repeated measure analysis controlling for gestational age and presence of bronchopulmonary dysplasia, was used to evaluate for significant difference between the three time points. The p value was associated with Type 3 Tests of Fixed Effects of Results Effects Model for repeated measurements. The "A" and "B" superscripts note a statistically significant difference between groups.

Figure: Left Ventricular Torsion from 32 weeks Postmenstrual Age, 36 weeks Postmenstrual Age, and at 1 Year Corrected Age in Preterm Infants with and without Bronchopulmonary Dysplasia.



Footnote: Postmenstrual age (PMA), Corrected age (CA), Bronchopulmonary dysplasia (BPD)

P2-149

Dobutamine Alters Normal Pattern of Mechanical Activity of the Heart: A High Resolution Speckle-Tracking Based Motion Analysis

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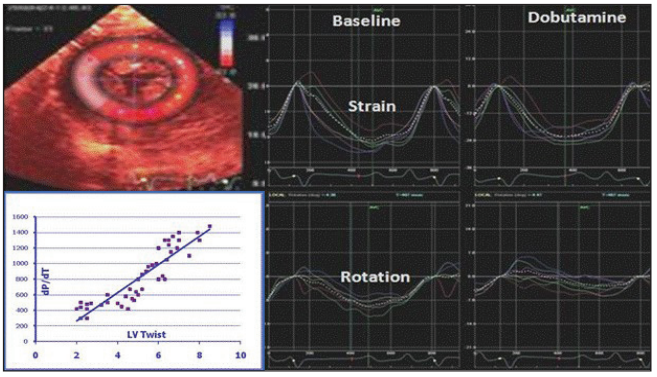
Background: Dobutamine is frequently used in stress testing We studied the impact of dobutamine on cardiac mechanics. **Methods:** Seven adult pigs underwent midline sternotomy under anesthesia to allow acquisition of very high frame rate images directly from the heart surface. Left ventricular (LV) pressure volume curves were obtained by Millar conductance catheters and apical short axis views acquired with a 10S probe on a Vivid 7 Dimension ultrasound system at >120 frames/second. After baseline image acquisition, pigs were subjected to escalating doses of dobutamine. Images for each state were obtained and analyzed. **Results:** At baseline, contraction initiated and peaked sooner in septal segments of LV apex with a delay of up to 10-12% of R-R' interval time between peaks of systolic contraction in the septum and the lateral wall segments (P10mcg/kg), with > 25% increase in heart rate the sequential pattern of contraction was lost, with 20-25% reduction in rotation as compared to baseline. Changes in LV rotation showed direct correlation with peak dP/dt. **Conclusions:** At higher doses, dobutamine alters cardiac rotation by changing the sequential contractile action of myocardial segments.



P2-150

Comprehensive (18 segment) RV Global Longitudinal Strain Assessment Compared to Apical 4 Chamber RV Strain Assessment - The Inter-Method Agreement and Feasibility in Normal Population

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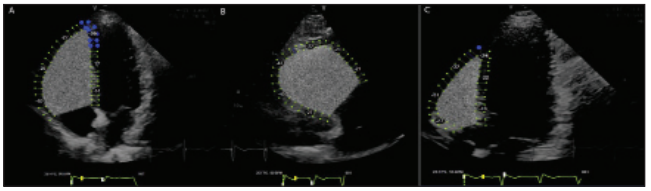
Background: Two dimensional speckle tracking echocardiography (2D STE) derived right ventricle (RV) global longitudinal strain (GLS) has emerged as an important predictor of clinical outcome in heart failure. RV focused apical-4 chamber (4-ch) view is currently the only recommended view for RV strain measurement, and there is no agreement on inclusion of septum for RV GLS measurement. In this retrospective study, we measured RV strain using an RV 18-segment model in 3 apical RV views (RV $GLS_{avg/3}$) 4-ch (A), 2-ch (B) and 3-ch (C) (Figure 1) and in focused apical RV 4-ch view (RV $GLS_{avg/4ch}$) to determine the feasibility and agreement between the 2 methods in normal population. **Methods:** Consecutive 69 transthoracic echocardiography studies of normal adults performed over a 3-month period were retrospectively identified from echo database to select 49 patients with no prior cardiovascular disease and with availability of all 3 apical RV views. 2D STE was performed off-line using Epsilon Imaging software from imported DICOM files. Clinical data was collected from medical charts. **Results:** The feasibility of RV GLS in all 3 apical RV views was 94.2% and in RV focused 4-ch view was 96.0%. Absolute value of RV GLS derived from 3 apical RV views (RV $GLS_{avg/3}$) and RV focused 4-ch view (RV $GLS_{avg/4ch}$) including septum were -29.3±2.9, and -29.55±2.4% and excluding septum were -33.4±3.7 and -32.1±2.7% respectively. For RV GLS measurement from 3 apical RV views, agreement with RV focused 4-ch view was better including septum (0.832) than excluding septum (0.676). Bland-Altman analysis (Figure 2) showed good agreement between RV $GLS_{avg/3}$ and RV $GLS_{avg/4ch}$ including or excluding septum (RV $GLS_{avg/3}$: mean bias, 0.25; RV $GLS_{FW/3}$: mean bias, -1.3). **Conclusion:** In normal population, 18-segment RV strain analysis from 3 apical RV views is feasible and comparable to 4-ch derived RV strain. It may provide a promising alternative for patients with heart failure or those with increased RV afterload states who require a more comprehensive RV strain analysis.



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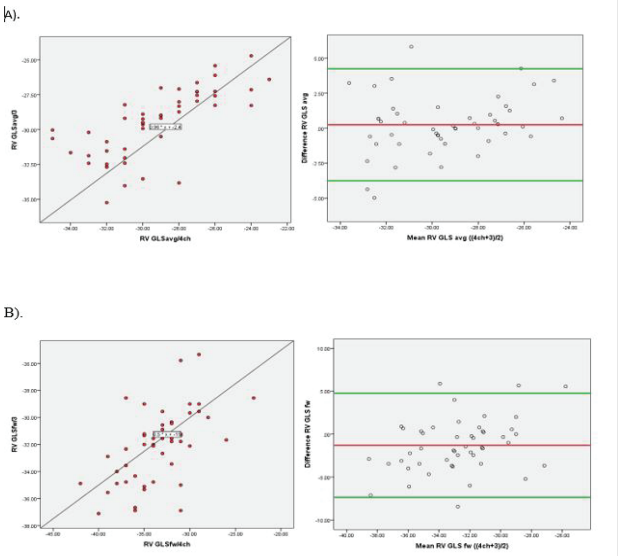

Figure1. Linear correlation and Bland-Altman plot for comprehensive 3-RV view-derived RV GLS compared to that from RV focused 4-ch view, including septum (A), and excluding septum (B). GLS was expressed as absolute value. Solid line in the linear correlation analysis represents line of identity. Red and green solid line in the Bland-Altman plot represent bias and 95% limits of agreement.

P2-151

Left Ventricular Global and Regional Longitudinal Strain as a Predictor of 1-Year All-Cause Mortality in Patients with Aortic Stenosis Undergoing Transcatheter Aortic Valve Replacement

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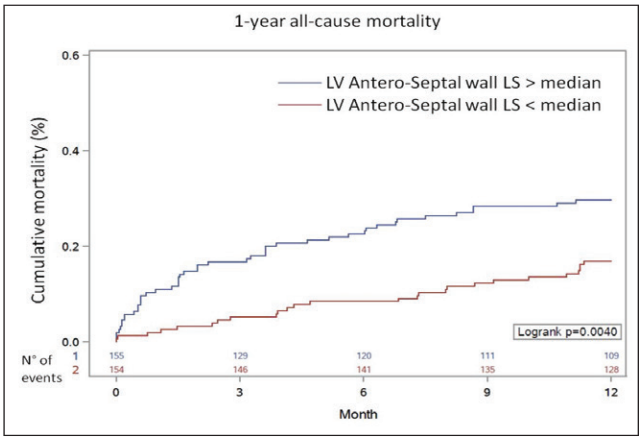
Background: Left ventricular (LV) global longitudinal strain (LS) has been proven to be of clinical value for diagnosis and patients' prognosis. Data is limited on the value of LV LS in patients with severe aortic stenosis (AS) undergoing transcatheter aortic valve replacement (TAVR). Accordingly, we aimed to determine the prognostic value of LV global and regional LS as predictors of 1-year all-cause mortality after TAVR. **Methods:** We retrospectively analyzed consecutive patients with AS in sinus rhythm who underwent TAVR between 2007 and 2014. LV global LS was derived from speckle tracking analyses (TOMTEC) from apical 2-, 3- and 4- chamber views. Regional analysis comparisons were performed both following the LV axis (base, mid and apical segments), as well as the 6 walls defined by ASE guidelines: anterior (AN), antero-lateral (AL), infero-lateral (IL), inferior (IN), infero-septal (IS), antero-septal (AS). Cox regression analyses for LV global and regional LS were performed to predict 1-year all-cause mortality and subgroups were created by their median to generate Kaplan Meier (KM) curves. **Results:** From a total of 613 consecutive patients, 359 (59%) were included for LV LS analysis (14% were excluded due to atrial fibrillation, 12% with pacemaker, 7% with bad quality images, and 8% with no available echo). Mean age was 83±8 years old, 43% were male and LV ejection fraction was 61±12%. Baseline measurements were as follows: global LS -20.31±4.7%, basal segments -19.0±4.4%, mid segments -19.4±4.3%, apical segments -24.9±7.5, AN wall -21.3±5.2%, AL -22.2±5.4%, IL -22.2±5.8%, IN -21.0±5.7%, IS -20.0±5.3% and AS -18.8±5.1%. Significant regional differences were found between the base and apex, and among the 6 walls (P<0.01). Cox regression analysis showed that only LV antero-septal wall LS had a trend as a predictor of all-cause mortality at 1-year (HR 1.04, 95% CI 0.99-1.09, p=0.09). KM curves showed that patients with worse LV antero-septal wall LS (above median of -19.0, i.e. less negative values) had higher all-cause mortality at 1 year (Figure). **Conclusions:** In a real world TAVR population, LV regional LS might detect patients with higher all-cause 1-year mortality risk. Further investigation is needed about TAVR effect in LV LS.



P2-152

Determining a Normal Reference Range of Left Ventricular Global Longitudinal Strain Measurements Using a State of the Art Philips EPIQ 7 Echocardiography System

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Background: Strain echocardiography (STE) is a newer and more sensitive tool that has shown promise in the evaluation of myocardial function. In particular, global longitudinal strain (GLS) measurements have been shown to identify early myocardial dysfunction and aid in myocardial disease prognosis. Widespread use of GLS in clinical practice has been limited by inter-vendor variability. In our study, we aim to define a normal reference range of left ventricular GLS values in patients with presumably normal myocardium using a specific ultrasound software system. **Methods:** We performed a retrospective study based on chart review of patients with presumably normal myocardium who underwent transthoracic echocardiography (TTE) with 2D speckle tracking echocardiography using the Philips EPIQ 7 Ultrasound System from November 2013 to October 2015. Each of the patients had left ventricular GLS determined as part of their clinical echocardiogram interpretation with the result included on the clinical echo report. **Results:** 135 patients (average age 47 ±13.4, male 34.1%) were included in the study out of 1864 patients at University of Michigan Health System who had a TTE including measurement of GLS using the Philips EPIQ 7 ultrasound system. Inclusion criteria for the study included age greater than 18 years old, absence of known cardiovascular disease or cardiovascular risk factors, and EF greater than 50% without any evidence diastolic dysfunction. The mean GLS for the group was -21.0 ± 2.6% with a lower limit of normal for the group of -15.8%. When separated out by gender, the mean GLS value for males was -20.1% ± 2.8% and for females was -21.5% ± 2.4%, respectively. There was a significant difference in GLS between females and males with no correlation noted between GLS and age. **Conclusion:** This study provides a normal baseline and reference range of values for left ventricular GLS measurements using the Philips EPIQ 7 ultrasound system in patients with no known underlying structural heart disease. These GLS values could be used as a reference range for future patient care and could also aid in the monitoring for subclinical changes in myocardial function.

Table 1: Demographics and Summary of GLS and Ejection Fraction

	Total	Male	Female
Age (Mean±SD)	47±13.4	47±14.7	46±12.7
Pre-Chemo (%)	80.9	44.7	100
Number of Patients	135	46	89
GLS % (Mean±SD)	-21.0±2.6	-20.1±2.8	-21.5±2.4
GLS % Upper Limit (Mean±2*SD)	-26.2	-25.7	-26.3
GLS % Lower Limit (Mean-2*SD)	-15.8	-14.5	-16.7
EF % (Mean±SD)	62.8±4.6	60.6±4.9	63.8±4.2

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Longitudinal Strain in Layer-Specific Myocardium in Early and Late Preeclampsia

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Aims: Early- and late-onset preeclampsia (PE) are thought to be different disease entities. Using the layer-specific strain, we compare the longitudinal strain (LS) in each of the

three myocardial layers in the patients with early and late PE to detect possible differences in the layer-specific myocardial deformation. **Methods:** Forty-five patients with early-PE (PE1 group), 44 patients with late-onset PE (PE2 group), and 86 normotensive pregnant women were included. Layer-specific LS were assessed in endocardium, mid-myocardium, and epicardium by 2-dimensional speckle-tracking echocardiography. **Results:** Compared to the control subjects, the LS of all the three analyzed myocardial layers showed a significant decline in PE patients. Lower myocardial deformation in the endocardial to mid-myocardial and epicardial layers were present in women with early-onset PE compared to late-onset PE. The endocardial-to-epicardial LS gradient was higher in early-onset PE women than late-onset PE group. **Conclusions:** More damage occurred in each of the three myocardial layers in early-onset PE versus late-onset PE. Compared to late-onset PE, more decreased of LS occurred in the endocardium which contributed to the increased endocardial-to-epicardial LS gradient in early-onset PE group.

Table1 Clinical and Hemodynamic Characteristics in Normotensive and Preeclamptic Pregnancy

Variable	N1	N2	PE1	PE2	N1 vs. PE1	N2 vs. PE2	PE1 vs.PE2
Number	44	42	45	44	n.s.	n.s.	n.s.
Age(y)	29.90 ± 6.15	31.03 ± 5.56	32.05 ± 6.42	31.88 ± 5.71	n.s.	n.s.	n.s.
GA(w)	28.20 ± 3.93	37.39 ± 2.89	28.94 ± 3.66	36.43 ± 2.23	n.s.	n.s.	<0.001
BMI(kg/m²)	23.57 ± 2.26	25.36 ± 2.15	28.01 ± 3.95	30.13 ± 3.20	<0.001	<0.001	n.s.
HR(bpm)	89.79 ± 10.89	83.62 ± 13.56	75.25 ± 12.35	82.70 ± 10.95	<0.001	n.s.	n.s.
SBP(mmHg)	104.12 ± 6.62	106.20 ± 7.94	152.81 ± 16.05	144.83 ± 13.53	<0.001	<0.001	<0.001
DBP(mmHg)	68.17 ± 7.15	71.08 ± 6.81	102.44 ± 13.67	98.59 ± 12.79	<0.001	<0.001	n.s.
RWT	0.30 ± 0.03	0.31 ± 0.03	0.39 ± 0.08	0.39 ± 0.09	<0.001	<0.001	n.s
EDVi(ml/m²)	49.89 ± 9.61	49.27 ± 8.65	60.34 ± 11.31	53.80 ± 8.34	<0.001	<0.05	<0.001
LVMi(ml/m²)	62.31 ± 8.70	65.42 ± 7.62	84.09 ± 10.24	75.29 ± 10.13	<0.001	<0.001	<0.05
SpI	0.28 ± 0.04	0.28 ± 0.08	0.38 ± 0.06	0.37 ± 0.10	<0.001	<0.001	n.s
EF(%)	65.54 ± 4.32	64.78 ± 4.62	61.64 ± 5.54	63.77 ± 4.76	<0.01	n.s.	n.s
LAd(mm)	25.27 ± 5.72	26.54 ± 6.19	33.90 ± 5.86	31.59 ± 6.41	<0.001	<0.05	n.s
E/e	0.12 ± 0.03	0.12 ± 0.06	0.19 ± 0.05	0.16 ± 0.10	<0.01	<0.05	<0.05

Table 2 LV Three-layer Longitudinal Strain in Normotensive and Preeclamptic Pregnancy

Longitudinal Strain (%)	N1	N2	PE1	PE2	N1 vs. PE1	N2 vs. PE2	PE1 vs.PE2
GLS-endo	23.97 ± 2.98	22.09 ± 2.16	16.60 ± 2.40	18.56 ± 3.20	<0.001	<0.001	<0.05
GLS-mid	21.03 ± 2.81	18.94 ± 2.77	14.25 ± 3.01	17.06 ± 2.80	<0.001	<0.01	<0.001
GLS-epi	18.61 ± 2.83	16.51 ± 2.57	12.31 ± 2.45	14.94 ± 2.47	<0.001	<0.01	<0.001
GLS-Avg	21.21 ± 2.80	19.18 ± 2.81	14.39 ± 2.92	16.89 ± 2.63	<0.001	<0.001	<0.01
P value (between layers)	<0.001	<0.001	<0.001	<0.01			

GLS indicates the global longitudinal strain at the basal, mid-ventricular and apical levels

Table 3 The Endocardial-to-epicardial Gradient of Longitudinal Strain in Normotensive and Preeclamptic Pregnancy

Endocardial-to-epicardial gradient(%)	N1	N2	PE1	PE2	N1 vs. PE1	N2 vs. PE2	PE1 vs.PE2
GLS	11.51 ± 3.13	13.17 ± 2.54	25.84 ± 2.97	19.50 ± 2.55	<0.001	<0.01	<0.001
Basal level	6.66 ± 1.57	7.49± 2.02	11.66 ± 2.18	10.76 ± 3.17	<0.001	<0.05	n.s
Mid-ventricular level	16.83 ± 2.40	15.70 ± 2.76	18.78 ± 2.58	13.96 ± 2.80	<0.05	<0.05	<0.05
Apical level	36.26 ± 3.28	41.03 ± 3.30	40.83 ± 2.76	31.65 ± 3.02	<0.01	<0.001	<0.001

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Arterial Stiffness Adversely Effects Ventricular-Vascular Interaction in Pediatric Cardiac Transplant Recipients

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Background: The interaction of the ventricle with the arterial system is a central determinant of cardiovascular performance. Cardiac transplant recipients may have vascular dysfunction due to exposure to various risk factors, but there are limited data available for that. We sought to determine the vascular changes and ventricular-vascular interaction in pediatric cardiac transplant recipients. **Methods:** A cross-sectional, prospective observational study was conducted. Transplant recipients (age 10-21 yrs), who received a heart more than 3 months ago and did not have any clinical or echocardiographic evidence for rejection, and healthy volunteers from the community were enrolled. Arterial stiffness was measured in the aorta by pulse-wave velocity (PWV) and augmentation index adjusted for heart rate (AIx) using a tonometer and in the carotid arteries using a vascular ultrasound to measure the carotid distensibility (% change). The ratio of non-invasive estimation of arterial elastance (Ea) to left ventricular end-systolic elastance (Ees) was used to calculate the arterial-ventricular coupling index (Ea/Ees). **Results:** Study population included 10 cardiac transplant recipients and 26 controls. A comparison of patient characteristics, echocardiographic and vascular measures is shown in the Table. The ejection fraction was similar in transplant recipients versus controls (63% (59-78) vs 64.2% (57, 71) respectively, p = 0.880). PWV and AIx were significantly increased in transplant recipients and the carotid distensibility was reduced (Table). Ea/Ees was worse in transplant recipients compared to controls. There was a significant positive correlation between Ea/Ees and AIx (r = 0.45; 95% CI (0.11, 0.68); p =0.01), and there was a significant negative correlation between Ea/Ees and carotid distensibility (r_s = -0.35; 95% CI (-0.60, -0.01); p = 0.038). **Conclusion:** Pediatric cardiac transplant recipients have stiffer arteries and abnormal ventricular-vascular interaction compared to healthy children. Increased AIx and reduced carotid distensibility correlates with worse ventricular-vascular coupling. These data suggest the need for further investigation to define any modifiable risk factors associated with the abnormal ventricular-vascular interaction in transplant recipients.

	Controls N = 26	Transplanted N = 10	P-value
Patient Characteristics (Mean ± SD)			
Age (years)	14.9 ± 2.9	17.3 ± 2.6	0.031
Gender (male%)	17 (65.4%)	8 (80%)	0.394
Height (cm)	164.27 ± 12.37	166.25 ± 10.02	0.625
Weight (kg)	56.33 ± 11.95	60.63 ± 15.54	0.444
BMI	20.6 ± 2.6	22.0 ± 5.5	0.472
Systolic BP	112.1 ± 10.7	118.8 ± 9.3	0.083
Diastolic BP	61.3 ± 10.7	69.5 ± 6.9	0.012
Echocardiographic and Vascular measures [Mean ± SD; median (range)]			
Ejection fraction (%)	63.92 ± 3.69 64 (57 , 71)	64.2 ± 5.18 63 (59 , 78)	0.880
Pulse wave velocity (m/sec)	5.1 ± 0.93 5.2 (2.93 , 7.1)	6.13 ± 1.04 6.13 (4.07 , 7.23)	**0.016**
Aortic augmentation index (AIx), (%)	-3.22 ± 10.2 -5 (-19, 14)	8.93 ± 13.6 6.5 (-8, 35)	**0.024**
Carotid distensibility (% change)	0.19 ± 0.03 0.18 (0.15 , 0.24)	0.16 ± 0.02 0.16 (0.14 , 0.19)	**<0.001**
Arterial elastance (Ea)	1.56 ± 0.25 1.56 (1.2 , 2.18)	2 ± 0.54 1.95 (1.27 , 2.77)	**0.032**
Left ventricular end-systolic elastance (Ees)	2.13 ± 0.55 2.01 (1.35 , 3.35)	2.26 ± 0.78 2.17 (1.07 , 3.7)	0.641
Arterial-ventricular coupling index (Ea/Ees)	0.75 ± 0.13 0.76 (0.51 , 0.97)	0.91 ± 0.12 0.92 (0.75 , 1.19)	**0.003**

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Right Ventricular Free Wall Longitudinal Strain as a Single Parameter to Determine Systolic Function in Elderly Population with Severe Aortic Stenosis

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Background: Although right ventricular (RV) systolic function (SF) has been shown to predict outcomes, its echocardiographic assessment is troublesome and depends on multiple parameters: fractional area change (FAC), tricuspid annular plane systolic excursion (TAPSE) and myocardial velocity (S'). RV free wall longitudinal strain (FW-LS) is a novel, sensitive echocardiographic parameter to evaluate SF. Its application in a population with severe aortic stenosis (AS) is not known. We aimed to assess FW LS to detect RV SF in a transcatheter aortic valve replacement (TAVR) population. **Methods:** We retrospectively analyzed consecutive patients with severe AS who underwent TAVR between 2007-2014 and had available 1-3 months pre- and 1-year post-procedural echocardiography in sinus rhythm. Patients with pacemaker were excluded. Conventional RV SF indices (TAPSE, S', FAC) were measured (Philips) and FW-LS was derived from speckle tracking analyses (TOMTEC). The standard reference was determined as normal or impaired RV SF according to the presence of at least 50% of the following: TAPSE<1.7cm, S'<9.5cm/s, FAC<35%. Logistic regression analysis was performed to predict impaired RV SF. **Results:** 15% of the patients were excluded due to image quality for FW-LS analysis. 146 patients were included for analysis. TAPSE was available in 75%, S' in 94% and FAC in 100% of these cases. By conventional RV parameters, 80% had normal RV SF while 20% had impaired RV SF. Baseline measurements were as follows for impaired/normal subgroups: TAPSE 1.3±0.3/2.2±0.4 cm, S' 8.2±1.5/11.9±2.3 cm/s, FAC 35±11/50±9%, FW-LS -21.3±6.4/-25.7±6.0% (p<0.05 for all). At 1 year post-TAVR, no significant change was seen for FW-LS compared to baseline measurements in either the impaired (-24.0±6.3%) or normal subgroups (-27.6±5.3%), with p<0.01 between them. In

a univariate logistic regression analysis, RV FW-LS was able to predict impaired SF (Odds Ratio 1.12, 95% CI 1.06-1.19, p<0.01). **Conclusions:** In a real-world TAVR population, RV FW-LS is a highly feasible single echocardiographic parameter which may assess RV SF by itself. Each single unit of RV FW-LS was associated with a 12% risk of impaired RV SF. Interestingly, RV FW-LS did not change significantly after 1 year follow up in either the RV impaired or normal subgroups. RV FW-LS should be considered for routine use in TAVR population to assess RV SF and predict impaired RV function.

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Comprehensive Assessment of Right Ventricular Systolic Function from the Subcostal Compared to the Apical View in Normal and Heart Failure Population - A Feasibility Study

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Background: Right ventricle (RV) is gaining increasing attention in patients with heart failure (HF). Systolic RV dysfunction is an independent predictor of morbidity and mortality in patient with HF. Apical RV images may be challenging in normal and especially HF population in real clinical practice. In this retrospective study we evaluated the feasibility of assessing RV systolic function in the subcostal view (SC) compared to those derived from the apical four chamber view (4-ch) in both normal and HF population. **Methods:** Out of 72 consecutive patients, 62 patients who had good quality RV images in a 30 day period on TTE were retrospectively selected from Echo lab database. 38 normal TTE studies were performed in normal healthy adults and 24 studies in patients with ischemic or non-ischemic cardiomyopathy. Tricuspid annular plane systolic excursion (TAPSE), fraction area change (FAC), RV peak longitudinal strain (RV GLS) and RV-arterial coupling parameters were measured in apical four-chamber (4-ch) and subcostal view (SC), respectively. PASP was calculated from TR signal and IVC. Feasibility and head-to-head comparison of all these RV functional parameters in both 4-ch and SC view was evaluated. **Results:** The values, correlation and feasibility of RV functional parameters in the 4-ch and SC views in normal and HF population are shown in **Table 1**. Correlation was better in HF population compared with those in normal control. Bland-Altman analysis (**Figure 1**) showed good agreement between all corresponding measurements derived from both echocardiographic views in HF as well as normal control, respectively and overall. **Conclusion:** SC window could be an eligible alternative for RV function assessment in normal and HF population. Further data is needed for validation and prognostic role of RV assessment in SC view.

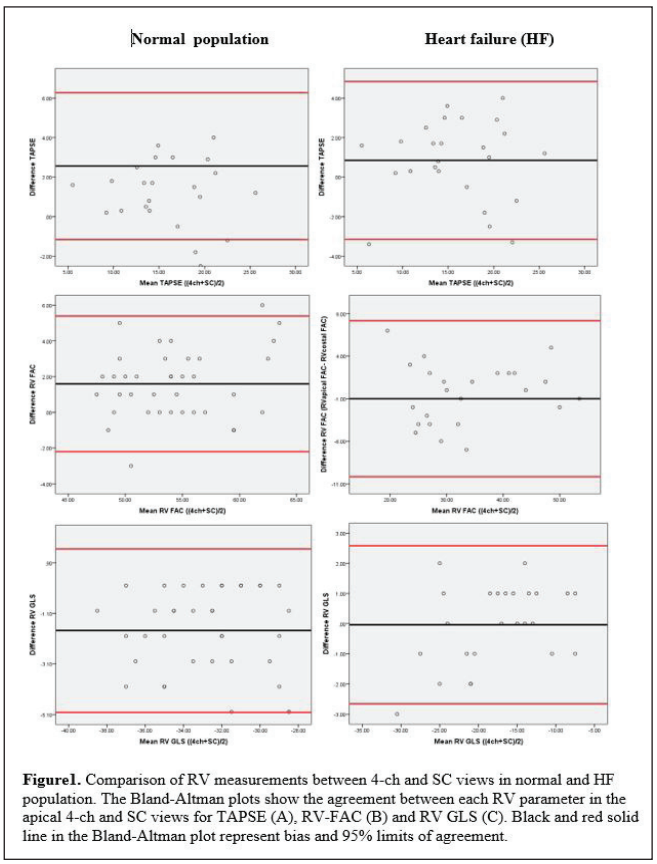

Figure1. Comparison of RV measurements between 4-ch and SC views in normal and HF population. The Bland-Altman plots show the agreement between each RV parameter in the apical 4-ch and SC views for TAPSE (A), RV-FAC (B) and RV GLS (C). Black and red solid line in the Bland-Altman plot represent bias and 95% limits of agreement.

Variables	Normal					Heart Failure (HF)				
Age (yrs)	58±12					69±11				
LV EDV (ml)	108.08±27.34					206.00±61.73				
LV ESV (ml)	37.83±13.06					148.8±53.31				
LV EF (%)	64.97±4.71					28.48±8.94				
	Apical 4-ch	Subcostal (SC)	r	p value	Feasibility (%)	Apical 4-ch	Subcostal (SC)	r	p value	Feasibility (%)
TAPSE (mm)	26.13±4.22	23.57±3.85	0.75	<0.001	95	16.25±5.26	15.41±5.27	0.91	<0.001	93
RV FAC (%)	55.11±4.93	53.5±4.48	0.74	<0.001	95	33.80±9.88	34.80±10.40	0.89	<0.001	93
RV GLS (%)	-29.65±2.72	-28.27±2.92	0.71	<0.001	93	-17.64±6.05	-17.64±6.05	0.95	<0.001	93
TAPSE-PASP ratio	1.01±0.20	0.91±0.17	0.88	<0.001	95	1.64±1.62	1.56±1.53	0.98	<0.001	93
RV GLS-PASP ratio	-1.10±0.21	-1.25±0.19	0.87	<0.001	93	-1.74±1.66	-1.77±1.70	0.97	<0.001	93

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Adaptive Changes in Right Ventricular Function Following Orthotopic Heart Transplantation in Children: A 2 Dimensional Speckle Analysis

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Background: Data are lacking on the evolution of right ventricular dysfunction noted in >50% of children following heart transplant. We aimed to evaluate right ventricular function longitudinally using speckle tracking echocardiography over one year following pediatric heart transplant. Our hypothesis was that, there would be progressive normalization of function in the initial year following heart transplant among children without allograft rejection. **Methods:** This single center observational study involved patients <18 years old of either gender who underwent heart transplant. Patients with clinical or biopsy-proven rejection were excluded. Echocardiograms at one month and one year following transplant were compared for right ventricular end systolic global longitudinal myocardial (RVGLSmyo) and endocardial (RVGLSendo) strain. RV was divided into two segments and peaks of free wall (RVFWpeak), and septal (RVSpeak) strain from apical four-chamber view were analyzed offline (Tomtec software) by a single reader. Other parameters included: RV myocardial performance index, ratio of RV systolic and diastolic duration, systolic duration time indexed to heart rate, ratio of tricuspid valve velocity to velocity time integral of the RV outflow at pulmonary valve and RV fractional area change. Paired t test was used to assess changes over time. **Results:** Of the 77 screened patients, 21 met inclusion criteria. There were 12 (57%) females with a mean ± SD age of 2.8 ± 3.8 (median 1.2) years. Indications for transplant were cardiomyopathy in 11 (52%), congenital heart disease in 8 (38%) and intracardiac tumor in 2 (10%) patients. Segmental peak longitudinal strains, and RVFWpeak significantly improved at one year post transplant, compared to 1-month, while improvement in RVGLSendo approached significance (p=0.05). Other RV echo parameters were similar at both time points. **Conclusion:** RV segmental strain measures on speckle tracking were impaired in the initial month following heart transplant but, in the absence of rejection, improved significantly over the first year, whereas the traditional RV function measures did not change over time. Speckle tracking echocardiography for RV function assessment may have utility in surveillance following heart transplant.

Parameters Mean ± SD or n (%)	Echo 1 (1 month)	Echo 2 (1year)
Time from Transplant to Echo	33.5±4.30 (days)	12.4±0.58 (months)
RVGLSmyo	-15.56±4.32	-17.4±3.16
RVGLSendo	-19.58±5.67**	-22.6±4.23**
RVFWpeak	-19.6±4.78***	-22.7±4.57***
RVSpeak	-18.46±7.09	-21.74±4.45
RVAVRpeak	-18.96±5.63***	-22.16±4.08***
RV myocardial performance index	0.18±0.07	0.19±0.17
Systolic to diastolic duration ratio	1.20±0.18	1.20±0.14
Systolic duration to systolic + diastolic duration ratio	0.54±0.03	0.54±0.03
Tricuspid regurgitant velocity to velocity time integral of pulmonary valve ratio	0.12±0.03	0.13±0.03
RV fractional area change	43.07±12.89	39.81±11.08

*** p value < 0.05, **p value = 0.05