P6-05 - Moderated

Novel Right Ventricular Three-Dimensional Strain Parameters Predict In-hospital Adverse Events of Isolated Tricuspid Valve Surgery

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Background: Isolated tricuspid valve surgery (ITVS) is considered a high-risk procedure. Right ventricular (RV) function plays a central role in the determination of surgical candidacy. Three-dimensional (3D) echocardiography has been shown to be superior to two-dimensional (2D) echocardiography in assessing RV function. In this study, we sought to use 3D-echocardiography derived novel RV strain parameters to predict in-hospital adverse events in patients undergoing ITVS. **Methods:** 2D and 3D transthoracic echocardiography was performed the day before ITVS. RV 3D strain parameters, including longitudinal strain, circumferential strain (RV-CS), and area strain, were calculated from serial RV surface meshes. Mesh generation and strain calculation were completed with commercially available software. In-hospital adverse events (AE) were defined as one of the following happened before discharge: death, shock, stroke, acute renal failure requiring dialysis, or prolonged (>72 h) mechanical ventilation. **Results:** A total of 56 patients (60 ± 10 years, 36% male, functional TR in 56%) were consecutively enrolled. In-hospital AEs were identified in 18 patients (32%) undergoing ITVS (2 death, 2 shock, 1 stroke, 2 renal failure, 11 prolonged mechanical ventilation). AEs pts scored higher in EuroSCORE and had longer cardiopulmonary bypass time. Age, hemoglobin, RV end diastolic volume, RV end systolic volume and RV-CS (-14±5 vs -18±5) were significantly different between pts with and without AEs (all $P<0.05$) while 2D/3D longitudinal strain and 3D RV ejection fraction were similar. In the multivariate logistic regression (age, atrial fibrillation, blood urea nitrogen, BNP, hemoglobin, RV end systolic volume, TAPSE, RV end diastolic volume, 3D RV ejection fraction, RV-CS), only hemoglobin and RV-CS were included in the final model. Among conventional and novel 3D RV function parameters, RV-CS demonstrated the highest ability to predict in-hospital AEs (area under the receiver-operating characteristic curve = 0.73, p=0.006). **Conclusion:** Calculation of novel 3D RV strain parameters is feasible in ITVS candidates. 3D RV-CS is reduced in surgical candidates who developed in-hospital AEs after ITVS. 3D RV-CS might help identify patients at risk of post-operative events in ITVS.

Figure 1. Examples for RV 3-dimentional model and parameters

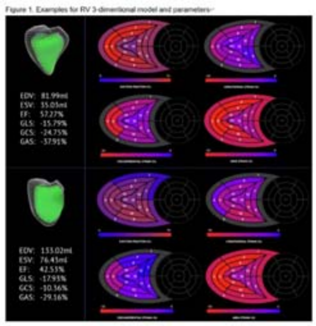

Figure 2. ROC curve of RV function parameters

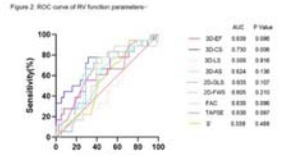

Table 1. Univariate and multivariate logistic analysis

Characters	Univariate			Multivariate		
	Odds ratio	95% CI	P-value	Odds ratio	95% CI	P-value
Age	1.095	1.016-1.180	0.018	/	/	/
Hemoglobin	0.971	0.947-0.995	0.020	0.967	0.940-0.995	0.019
RV EDV	1.011	1.002-1.020	0.020	/	/	/
EV ESV	1.017	1.003-1.032	0.018	/	/	/
3D RV-CS	1.230	1.047-1.445	0.012	1.256	1.050-1.503	0.013

EDV, end diastolic volume; ESV, end systolic volume; 3D, 3-dimentional; RV, right ventricle; CS, circumferential strain

P6-06

Fourth dimension, 10-fold faster: Dynamic segmentation of 3D-transesophageal echocardiography (3D-TEE) using an automated neural network for MitraClip transcatheter edge-to-edge repair (TEER)

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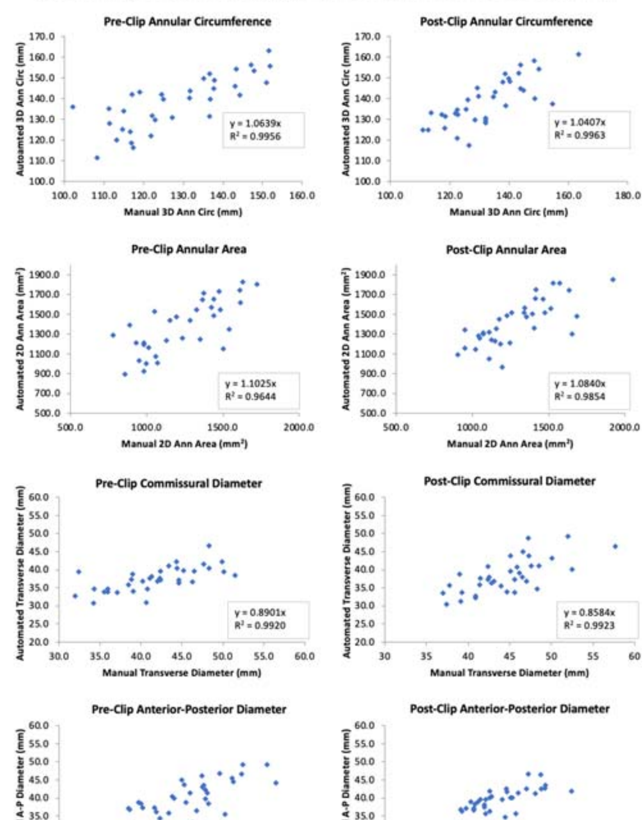
Background: Patient outcomes after MitraClip TEER have been shown to correlate with anatomic indicators such as mitral annular area, circumference, ellipticity, and tenting height. However, current technologies for assessing these indices are limited by single time-point segmentation of 3D-TEE. A novel method using an automated neural network and deformable registration allows for dynamic segmentation throughout the cardiac cycle, permitting 4D measurements. **Methods:** We studied 43 patients undergoing MitraClip for both primary and secondary mitral regurgitation. We used an automated, open-source neural network (nnU-Net) trained on both normal and abnormal valves to segment these images in a single mid-systolic frame pre- and post-clip. We then propagated the 3D annular reconstruction through the cardiac cycle using deformable image registration. To validate the annular analysis, we correlated the automated, propagated mid-diastolic measurements to manual mid-diastolic measurements made by a single, blinded user in QLAB (Philips, Amsterdam, NE). **Results:** Dynamic segmentation of the mitral valve was successful in 35 of 43 patients (81.4%), with 6 patients (14.0%) failing due to poor image quality and 2 patients (4.6%) failing due to incompatible image formats. Manual segmentation was successful 41 of 43 patients (95.3%) with 2 (4.6%) failing due to poor image quality. Manual segmentation required an average of 8 minutes of user interaction per case compared with 45 seconds per dynamic segmentation (10:1). With the exceptions of annular height and ellipticity, measurements derived from propagated segmentations were positively correlated with manually obtained measurements (Table 1, Figure 1). **Conclusions:** Dynamic segmentation of 3D-TEE via an automated neural network provides accurate, expedient measurements of mitral annular geometry (circumference, area, and diameters). Further study of these dynamic indices may better optimize outcomes of MitraClip TEER.

Table 1. Correlation of Automated, Propagated Measurements with Manual Mid-Diastolic Measurements (n = 35) for 6 Mitral Annular Indices, Pre- and Post-Mitra Clip

Statistic	Correlation Coefficient	P value
Pre-Clip Automated vs. Manual Annular Circumference	0.7338	<0.05
Pre-Clip Automated vs. Manual Annular Area	0.6834	<0.05
Pre-Clip Automated vs. Manual Commissural Diameter	0.6728	<0.05
Pre-Clip Automated vs. Manual Anterior-Posterior Diameter	0.7143	<0.05
Pre-Clip Automated vs. Manual Ellipticity	0.2784	NS
Pre-Clip Automated vs. Manual Annular Height	0.1011	NS
Post-Clip Automated vs. Manual Annular Circumference	0.7642	<0.05
Post-Clip Automated vs. Manual Annular Area	0.7511	<0.05
Post-Clip Automated vs. Manual Commissural Diameter	0.7043	<0.05
Post-Clip Automated vs. Manual Anterior-Posterior Diameter	0.5097	<0.05
Post-Clip Automated vs. Manual Ellipticity	0.4481	<0.05
Post-Clip Automated vs. Manual Annular Height	0.1983	NS

*Automated measurements derived from segmentations propagated forward from systole, with automated selection of largest values in diastole

Figure 1. Linear Regressions of Automated, Propagated Measurements with Manual Mid-Diastolic Measurements (n = 35) for Statistically Significant Mitral Annular Indices, Pre- and Post-MitraClip



P6-07

3D Echocardiography Guidance for Pacemaker Lead Placement Improves Accuracy of Lead Placement and Reduces QRS Duration Compared to Fluoroscopic Guidance

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Background: Transvenous pacemaker leads placed in the right ventricular (RV) free-wall can be associated with increased paced QRS duration and subsequent pacemaker-induced cardiomyopathy. With traditional fluoroscopic guidance, leads are often mistakenly placed in the free-wall, rather than the ventricular septum. Our aim was to determine if the use of transesophageal 3D echocardiography (3DE), which visualizes anatomy and pacemaker leads well, could improve the accuracy of lead placement in the ventricular septum and result in shorter paced QRS duration. **Methods:** In 59 patients, 3DE was used to guide pacemaker leads to desired locations, where they were secured; fluoroscopy was used sparingly as needed for lead movement, securing leads, or slack adjustment. Lead location was recorded by echocardiography, and (in those that had it) CT or MRI. Paced QRS duration was measured in RV leads. Cases were compared to 72 historical control pacemaker cases, which used only fluoroscopy for lead implant, by Wilcoxon rank sum, Pearson's chi-square or Fisher's exact tests. **Results:** When RV lead location was assessed by echocardiography, using 3DE guidance, 78.4% of RV leads were placed in the septum, 17.7% were placed in the junction between septum & free-wall, and only 3.9% were placed in the free-wall, compared to 29.8%, 12.8% and 57.4% by fluoroscopic guidance (respectively) (P<0.001 for proportions between the two groups, and between free-wall and septal locations) (Table 1). This trend was also seen in the limited number of patients that had a subsequent CT or MRI. Of the two RV leads placed in the free-wall while using 3DE guidance, one was an ICD-only lead, and in the other, the ICD+pacemaker lead was guided to the septum but pacing parameters were not tolerable and thus the free-wall was used. QRS duration was significantly shorter in patients that had 3DE guidance with the lead placed in the septum (129msec, IQR 117-143) compared to those with fluoroscopic guidance alone (141.5msec, IQR 134-148) (P=0.031). **Conclusions:** Use of 3DE guidance for pacemaker lead placement results in more accurate placement in the septum and shorter QRS duration than fluoroscopic guidance. 3DE guidance for lead placement could reduce the long-term risk of pacemaker-induced cardiomyopathy and should be considered for all pacemaker lead placements.

Table 1

Variable	3D Echo Guidance (n=59)	Fluoroscopic Guidance (n=72)	P-value	
Demographics				
Female	26 (44.1%)	37(51.4%)	0.483	
Height (cm)	160 (150-169)	164 (154-170)	0.395	
Weight (kg)	58.9 (47.0-72.9)	55.2 (46.0-65.8)	0.338	
BSA (m²)	1.65 (1.43-1.82)	1.59 (1.39-1.75)	0.468	
RV Lead location by Echo	(n=51)	(n=47)		
Septum	40(78.4%)	14(29.8%)	<0.001	
Free-Wall	2(3.9%)	27(57.4%)	<0.001	<0.001
Septal/Free-Wall Junction	9(17.7%)	6(12.8%)	0.582	
RV Lead Location by CT/MRI	(n=5)	(n=16)		
Free-Wall	0(0.0%)	11(68.7%)		
Septum	3(60.0%)	4(25.0%)		0.076
Septal/Free-Wall Junction	2(40.0%)	1(6.3%)		
QRS Duration (msec)	133 (118-163)	141.5 (134-148)	0.084	
	3D Echo Guidance + RV Lead Placed in Septum	Fluoroscopic Guidance		
QRS Duration (msec)	129 (117-143)	141.5 (134-148)	0.031	

P6-08

Deep Learning Analysis of 3D Echocardiography Demonstrates Superior Identification of Left Ventricular Remodeling and Hypertrophy

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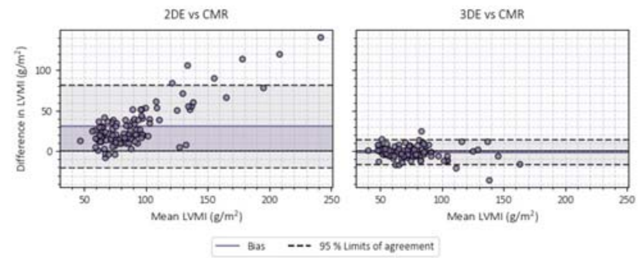
Background: Changes in left ventricular (LV) geometry are associated with increased mortality and morbidity, independent of age, gender, or hypertension. Cardiac structure is routinely assessed by 2D echocardiography (2DE), but discrepancies exist when compared to the gold standard of cardiac magnetic resonance (CMR) imaging. Advances in 3D echocardiography (3DE) and machine learning can help to better characterize LV geometry. This study aims to: i) quantify the differences in geometric measurements assessed by 2DE/3DE and CMR, and ii) evaluate the utility of 3DE in the classification of LV remodeling. **Methods:** A total of 105 subjects (52 healthy controls and 53 with confirmed or suspected cardiac disease) underwent transthoracic (2D and 3D) echocardiography and cine CMR imaging, <1 hour apart. Indices used to classify LV remodeling from 2DE (i.e., LV mass index and relative wall thickness) were derived from linear measurements of the interventricular septum, LV internal diameter, and posterior wall thickness, as per ASE/EACVI guidelines. For 3DE, the LV was segmented automatically using a deep learning algorithm trained using labels from CMR, from which relevant dimensions and a direct mass could be computed. Finally, 3D LV models were constructed from CMR using validated software. With each modality, subjects were classified as exhibiting normal geometry, concentric remodeling, concentric hypertrophy, or eccentric hypertrophy, according to guidelines. **Results:** Statistically significant differences (p<0.01) were found between 2DE and CMR for all indices, but only LV internal diameter was significantly different between 3DE and CMR. Of note, for LV mass index, 3DE showed excellent reliability, narrower limits of agreement, and no apparent proportional bias (which was present for 2DE) (Figure 1). Of the 105 subjects, 32 exhibited non-normal geometry as identified by CMR. We found good agreement in LV remodeling classification between 3DE and CMR of 81 %, compared with 42 % agreement obtained with 2DE. **Conclusions:** Despite advances in 2D imaging, significant discrepancies in routine measurements still exist between 2DE and CMR. We found 3DE to demonstrate superior accuracy in the characterization of LV geometry and detection of structural remodeling over 2DE, which could be prognostically important.



P6-09

Normal Values of Left Ventricular Volumes and Function Measured by Automated Quantitative Three-Dimensional Echocardiography: A China Multicenter Study

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Background: Guidelines suggest the application of three-dimensional (3D) echocardiography to evaluate left ventricular (LV) volumes and function. However, manual 3D echocardiography is complex, time-consuming, and empirically reliant, which makes it hard to popularize in clinical applications. Recent studies have demonstrated that fully automated 3D echocardiography quantification software, dynamic heart model (DHM), can easily, rapidly, and accurately quantify LV size and function. But because the values measured by DHM were inconsistent with manual 3D echocardiography, inadequate reference values limited its extensive application. This study aims to determine LV volumes and function measured by the DHM based on a large multicenter study in China. **Methods:** The healthy adult volunteers of different sexes and ages were obtained from 55 centers. All subjects underwent 3D echocardiography and DHM for the quantification of LV end-diastolic volume, LV end-systolic volume, and LV ejection fraction (LVEF). **Results:** A total of 854 (376 men, mean age: 45 ± 14 years) healthy subjects were recruited in this research. Mean normal values for LV end-diastolic volume, indexed end-diastolic volume, LV end-systolic volume, indexed end-systolic volume, and LVEF in men and women were 116 ± 23 ml and 100 ± 18 ml, 64 ± 11 ml/m^2 and 62 ± 10 ml/m^2, 43 ± 11 ml and 34 ± 8 ml, 24 ± 6 ml/m^2 and 21 ± 5 ml/m^2, 63% ± 5% and 66% ± 5%, respectively. Men had larger LV volumes and lower LVEF than women. With increasing age, LV volumes decrease but LVEF increases. When body surface area increased by 0.1 m^2, LV end-diastolic and end-systolic volumes increased by 5.6 and 2 ml, respectively. The measurement of DHM is fast (mean 18 s) and well reproducible (intra-class correlations of 0.80 to 0.99 and coefficients of variation of 0.27 to 9.18). **Conclusion:** This research established normal values for LV volumes and function as measured by DHM, which is efficient and reproducible. The effects of age, gender, and body size on patients should be fully considered in clinical practice.

P6-10

Evaluation of Left Atrial Function & Prediction of Risk Stratification in Patients with Hypertensive Disorder of Pregnancy by Four-dimensional Automatic Left Atrial Quantitative Analysis

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Objective: To investigate the change of left atrial volume in patients with hypertensive disorders of pregnancy (HDPs) by four-dimensional automatic left atrial quantitative analysis (4D LAQ)and analyze the prediction of risk stratification. **Methods:** 60 patients diagnosed with hypertensive disorder of pregnancy in our hospital were randomly enrolled , which was divided into gestational hypertension group (low risk group, n = 30) and preeclampsia group (medium and high risk group, n = 30) according to the disease development and risk stratification method reported in the literature; another 30 healthy pregnant women matched for age, BMI were selected as the control group. Left atrial volume and strain parameters were obtained using 4D LAQ technique, including left atrial volume (LAVmin,LAVmax), left atrial presystolic volume (LAVpreA), left atrial maximum volume index (LAVImax),left atrial stroke volume (LAEV), longitudinal strain of left atrial reserve, conduit and systolic period(LASr, LAScd, LASct), circumferential strain of left atrial reserve, conduit and systolic period(LASr-c, LAScd-c, LASct-c). **Results:** Compared with the control group, LAScd-c were increased, and LASr, and LASr-c were decreased in the gestational hypertension group (all P < 0.05); Compared with the control group and gestational hypertension group, LVMI, E/e' LAVmin, LAVmax, LAVpreA, LAVImax, LAEV, LAScd, and LAScd-c were increased, and LApEF, LASr, and LASr-c were decreased in the preeclamptic group, and the differences were statistically significant (all P < 0.05). LAVmax, LAScd-c and LASr (β= 0.344, 0.216 and -0.249, respectively, all P < 0.05) were the indicators relevant with risk stratification of HDPs. ROC analysis showed when the cut-off value of left atrial strain parameter LASr was 30.5%, the AUC, sensitivity, and specificity were 0.725, 58%, 90%, respectively; when the cut-off value of LAVmax was 44.5ml, the AUC, sensitivity, and specificity were 0.662, 80%, and 56%, respectively;) and when the cut-off value of LAScd-c were -17.5%, the AUC, sensitivity, and specificity were 0.706, 56%, and 78%, respectively. **Conclusions:** Left atrial remodeling occured in pregnant woman with hypertensive disorders, their reserve and conduit function were impaired, and aggravated with the progress of the disease. The four-dimensional parameters LASr, LAVmax, and LAScd-c were relevant