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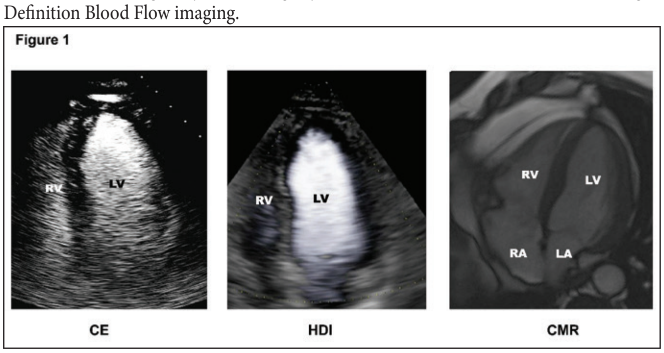
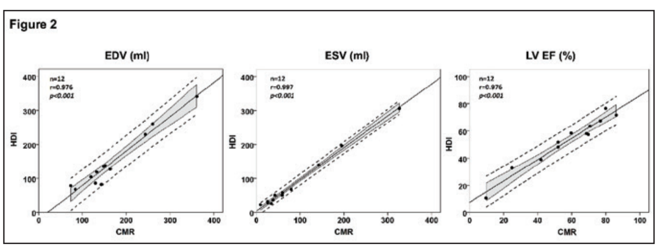
from 0.97 to 0.99 in comparisons between HDI and CMR (Figure 2), and from 0.94 to 0.96 in comparisons between CE and CMR. The limits of agreement for the inter-methods comparisons by Bland-Altman analysis (mean ± 1.96 SD) between HDI and CMR for LVEF, EDV, and ESV were 5.02 ± 12.5 %, 19.87 ± 36.4 ml and 2.51 ± 17.21 ml respectively, and between CE and CMR, 1.91 ± 11.92 %, 22.48 ± 53.84 ml, and 9 ± 46.55 ml respectively. **Conclusions:** Assessment of LV size and function by High-Definition Blood Flow imaging correlated well with CMR. Using CMR as the gold standard, the agreements in measurements of LV volumes were slightly superior for High-Definition Blood Flow imaging compared to contrast echocardiography. In measurements of LV ejection fraction, contrast echocardiography showed slightly less mean difference when compared to High-Definition Blood Flow imaging.





P2-067

Echocardiography-Based Three-Dimensional Printing for Sizing and Positioning of Percutaneous Left Atrial Appendage Occluder Device

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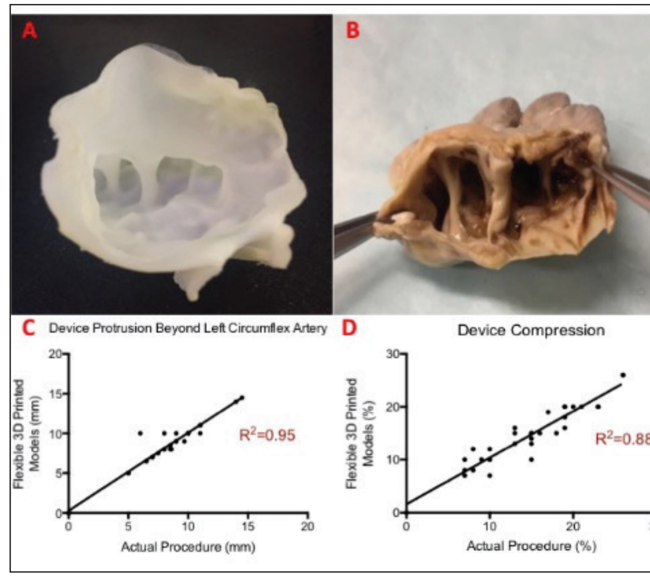
Background: Accurate sizing and positioning of percutaneous left atrial appendage (LAA) occlusion (LAAO) device underscores the importance of understanding LAA anatomy and tissue-device interaction. 3D printing using tissue-mimicking materials allows creation of patient-specific models for simulation of interventional procedure. We aim to evaluate the accuracy of LAAO device sizing and positioning on 3D-printed LAA models. **Methods:** 3D tranesophageal echocardiography (TEE) datasets of 57 patients (age=72±9, 39 men) undergoing LAAO [WATCHMAN (n=32); Amulet device (n=25)] were converted to physical LAA models by 3D printing (Connex 3; Stratasys) using flexible materials (Agilus Clear; Stratasys). Device size, position, and compression on the printed models were compared with that observed in the actual procedure. **Results:** 3D printing was feasible in all subjects. The maximal (24.2±3.3mm vs. 23.9±3.3mm), minimal LAA orifice diameters (19.4±4.4mm vs. 19.2±3.2mm), and LAA depth (27.7±6.4mm vs. 27.1±6.1mm) were similar when measured on 3D datasets and printed models (all p=NS). Printed models recreated pectinate muscles of surgical specimens accurately (Fig. A & B). Device testing accurately determined optimal device size in all patients (100%), in contrast to only 71% by 3D TEE (p<0.05). Device shoulder protrusion beyond LAA ostium (r^2=0.95) and device compression (r^2=0.88) in the simulated procedure correlated closely with the actual procedure (both p=NS) (Fig. C & D). **Conclusion:** Echocardiography-derived 3D printed models provides incremental information on LAA anatomy and tissue-device interaction that may allow more accurate device sizing and positioning than conventional 2D/3D imaging guidance.



P2-068

Handheld Wireless Digital Phonocardiography for Machine Learning-Based Detection of Aortic Stenosis

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Background: Aortic stenosis (AS) is a common disease which can be detected as a murmur on auscultation, but studies show that up to 80% of new primary care physicians do not detect AS murmurs which are confirmed by transthoracic echocardiography (TTE). The FDA-approved Eko CORE device is a digital stethoscope wirelessly paired with the Eko Mobile application to allow recording and analysis of phonocardiograms (PCG). These PCG data drive a machine learning-based detection algorithm to identify clinically significant AS, validated by TTE, as part of the ongoing Phono- and Electrocardiogram Assisted Detection of Valvular Disease (PEA-Valve) Study. **Methods:** Patients undergoing TTE at Northwestern Medicine underwent PCG recording by the Eko CORE device. Recordings 15 seconds long were obtained at four standard auscultation positions. A TensorFlow-based machine learning algorithm assessed the presence or absence of murmur with dominant localization to the right upper sternal border indicating clinically significant AS, defined as moderate or greater on TTE (Figure 1). **Results:** To date, 161 patients with 639 recordings have been enrolled, with 14 patients (8.7%) found to have significant AS on TTE. The receiver-operating characteristic curve had an area of 0.964, yielding a sensitivity of 97.2% (95% CI, 84.7-99.5%) and a specificity of 86.4% (95% CI, 84.0-88.7%) for the detection of AS (Figure 2). **Conclusion:** PCG assessment using the Eko CORE device and machine learning interpretation is a fast and effective method to screen for significant AS and should be validated in a primary care setting, which may lead to more appropriate referrals for echo.

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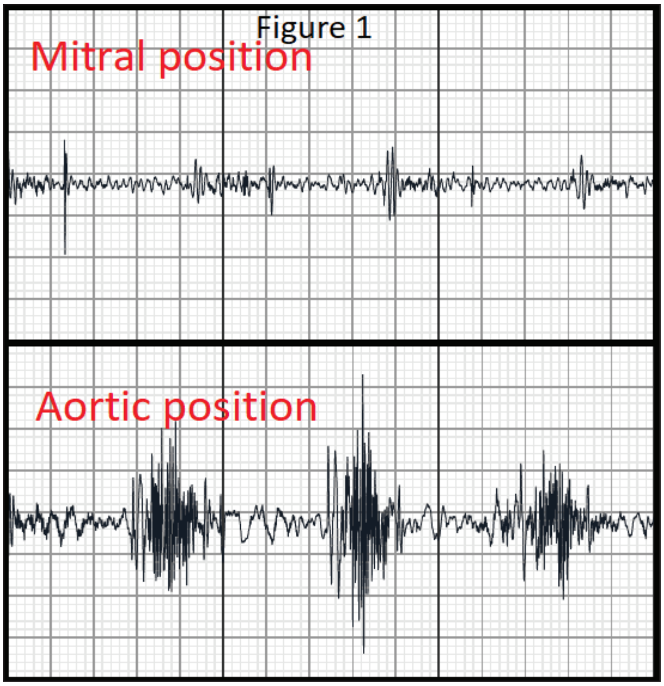

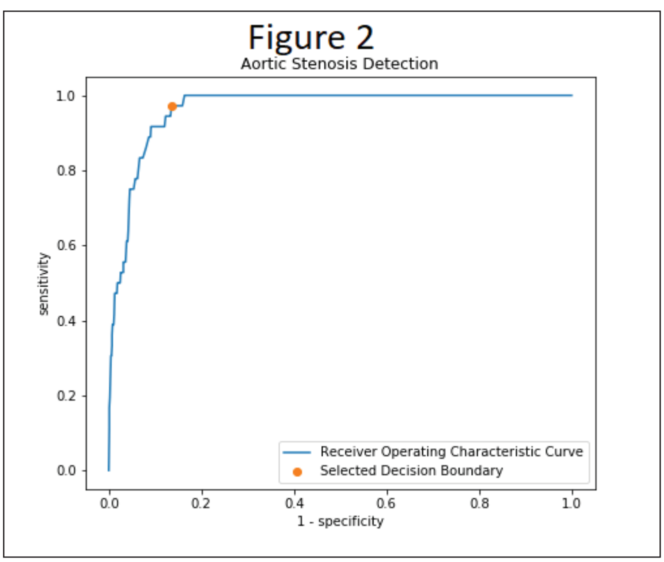

P2-069

Planning Structural Heart Interventions: Comparison of Measurements Made on Volume Rendered 3D Virtual Reality Models Versus Conventional 3D Software

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Background: Accurate measurements of cardiac structures, particularly valves, are critical for planning valvular interventions. Three-dimensional echocardiography (3DE) is time consuming because measurements require expertise with multiplanar reconstruction (MPR) to manipulate 3D datasets and knowledge of specialized software. We have developed a workflow to create dynamic, volume rendered virtual reality (VR) models from 3DE datasets and a VR environment that enables intuitive manipulation and measurements of cardiac structures while reducing the need for prior experience. The purpose of this study was to compare the time, accuracy and variability of measurements made with conventional software (TOMTEC 4D Cardio-View™) to those made on VR models in the VR environment. **Methods:** Datasets from 30 patients who underwent a clinical 3D transesophageal echocardiogram (TEE) to evaluate aortic valve (AV) or mitral valve (MV) pathology were used in this study (15 datasets each). Each dataset was converted into a 3D VR model using the novel algorithm. Blinded measurements independently performed by three users (ranging from novice to experienced) were made using conventional MPR and the custom VR environment using headsets and hand controllers. Common clinical measurements of the AV (left ventricular outflow tract (LVOT) diameter, AV area) and MV (anterior-posterior (A-P) and anteromedial-posterolateral (AM-PL) diameters and MV annular circumference) were performed. **Results:** All (30/30) TEE datasets were successfully converted and loaded into the novel VR environment in under 2 minutes. Measurements made in VR of all AV and MV parameters had lower variability than the same measurements performed using conventional software (Table). Furthermore, the times required to perform measurements in VR was shorter than the times using conventional software (Table). **Conclusion:** This is the first study to demonstrate that measurements made on VR models obtained from 3DE datasets have lower variability and are faster than those made using conventional methodology. Using a VR environment to analyze and measure 3DE-based models is a promising new tool to plan and guide structural interventions that offers the advantage of true 3D visualization and interaction.

Intraobserver Variability n = 15 for each measurement		4D CARDIO-VIEW™ Bias ± LOA (%)	Virtual Reality Bias ± LOA (%)
MV	A-P Diameter (cm)	1.4 ± 13.4	-0.7 ± 9.3
	AL-PM Diameter (cm)	3.0 ± 17.0	0.3 ± 9.2
	Annul Circumference (cm)	-0.1 ± 13.4	-2.4 ± 8.0
	Annular Area (cm²)	-0.1 ± 23.8	-4.0 ± 16.7
AV	LVOT Diameter (cm)	-0.1 ± 16.1	-0.8 ± 8.5
	Area Circumference (cm)	-3.4 ± 8.3	0.8 ± 8.6
	Area (cm²)	-7.0 ± 14.6	0.4 ± 14.1

Mean Measurement Time Each MV: n = 135 (VR) n = 45 (CV)	Each AV: n = 105 (VR) n = 30 (CV)	4D CARDIO-VIEW™ Mean Time (s)	Virtual Reality Mean Time (s)
MV	A-P Diameter (cm)	96.4	48.1
	AL-PM Diameter (cm)	32.7	18.9
	Annulus Circumference (cm)	77.0	65.1
	Annular Area (cm²)		
AV	LVOT Diameter (cm)	75.6	83.5
	Area Circumference (cm)	80.8	69.3
	Area (cm²)		

P2-070

Functional 3D Printed Modeling of the Mitral Apparatus for MitraClip Intervention

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Background: The MitraClip procedure is a catheter-based treatment for patients with severe mitral regurgitation (MR) and prohibitive surgical risks. The evaluation of multi-jet residual MR after MitraClip can be challenging. We sought to test if 3D printed models could be useful tools for the assessment of post-MitraClip hemodynamic conditions. **Methods:** En-face and long-axis 3D transesophageal echocardiographic (TEE) imaging datasets (systole) were used for the reconstruction of five patient-specific MV apparatus models. MitraClip devices were implanted in all five multi-material 3D printed MV models and each post-MitraClip construct was coupled into a flow loop and subjected to the patient-specific systolic hemodynamic condition. Post-MitraClip geometry and residual MR was evaluated using echocardiographic imaging and standard flow measurements. **Results:** Five functional patient-specific, multi-material 3D printed models of the MV apparatus and left ventricle (LV), including chordae, papillary muscles and left ventricle outflow tract were generated using a co-registration technique (Figure A). Each anatomical element was printed of different materials with appropriate mechanical properties suitable to mimic native valve tissue behavior. Selected 3D print materials for the leaflets and chordae were flexible enough for implantation of MitraClip devices as demonstrated in two specific patients (Figure B). Color Doppler images captured from models compared favorably to actual patient post-MitraClip implantation images (Figure C). Residual MR in the models with single or multiple MitraClip devices was quantified. The measurements showed a significant reduction of MR (up to 77%) within the tested models. This finding corresponded well to the actual MR reduction observed in the patients (Figure C). **Conclusion:** Functional MV apparatus models can be accurately reconstructed using 3D echocardiographic images. 3D printed models can be used for the benchtop implantation of MitraClip devices and resemble the clinical deployment. When subjected to patient-specific hemodynamic conditions, 3D printed models with implanted MitraClip devices are suitable for mimicking the realistic residual MR found in specific patients and allow for the in vitro assessment of MR after MitraClip deployment.