1231 Three-Dimensional Echocardiography in Congenital Heart Disease

Wednesday, April 1, 1998, 3:00 p.m.–5:00 p.m.
Georgia World Congress Center, West Exhibit Hall Level
Presentation Hour: 3:00 p.m.–4:00 p.m.

1231-119 Quantitative and Qualitative 3-Dimensional Echocardiographic Evaluation of Aortic Coarctation Using a Fast Fan-like Data Acquisition With an Integrated 3-D System: In Vitro Validation

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Background: Rotational data acquisition has been shown to provide 3D echo (3DE) images of aortic abnormalities. In this study, we explored the quantitative accuracy of 3DE, and the potential of a new integrated 3DE instrument with rapid fan-like image acquisition, in aortic coarctation (AoC).

Methods: In 10 explanted pig hearts with intact aortic tree, AoC of varying severity was experimentally created. These were imaged in a water-bath using the prototype (Esaote) 3DE instrument that rapidly steered a 7 MHz array at 1.25 degree intervals over a 60 degree arc within 2 sec. Using a fast quantification algorithm incorporated in the unit, we measured the area, perimeter and diameters of the narrowed AoC segment. These were compared to anatomic measurements from aortic specimens.

Results: In all experiments, we were able to review the aortic images in 3 dimensions instantly after data collection and section them in any desired plane. The pre-stenotic, stenotic and post-stenotic aortic segments could be visualized crisply. We could also obtain quantitative data immediately. The correlation between anatomy and 3DE were: *AoC area:* $y = 1.13x - 0.6$, $r = 0.98$, $p < 0.0001$; *Perimeter:* $y = 1.06x + 1.06$, $r = 0.96$, $p < 0.0001$; *Max diameter:* $y = 1.01x + 0.48$, $r = 0.92$, $p < 0.0001$; *Min diameter:* $y = 0.83x + 2.46$, $r = 0.87$, $p < 0.001$.

Conclusion: This mode of 3DE, when refined into a transthoracic or transesophageal tool, could be of value in reliable quantitation of the severity of aortic coarctation and in planning catheter-based interventions.

1231-120 Impact of 3-Dimensional Echocardiography in the Assessment of Atrial Septal Defect Device Occlusion

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Background: To optimize the results of ASD device occlusion (CardioSEAL, Nitinol Medical Technologies), precise information about defect number(s), size, location, and device position during implantation is critical. The purpose of this study was to define the clinical application of 3D echo in the assessment and monitoring of patients undergoing ASD device occlusion.

Methods: Since 11/96, 36 cases (median age 8.6 yrs) were evaluated by transesophageal echocardiography (TEE) for potential ASD device occlusion as part of a hospital approved trial. In all 36, 3D data were acquired using a Hewlett-Packard software and multiplane TEE probe. 3D images of ASD were reconstructed using the TomTec system. Fifteen cases have undergone device occlusion (awaiting implantation: 6, not suitable: 15). 3D images were reconstructed after procedure in all 15, and during the procedure in 12. The Maximal ASD diameter was measured from 3D echo and compared with dimensions measured by 2D TEE and fluoroscopy balloon sizing.

Results: 3D images demonstrated clear anterior ASD margin and the extent of deficient anterior rim in 33. The inferior-posterior border of the ASD was clearly delineated in 20. Maximal ASD diameter by 3D echo correlated with balloon ASD size ($p = 0.02$, $r = 0.68$). In 1 case with an elongated oval shaped defect, balloon sizing, by modifying the ASD morphology, clearly underestimated its dimension. After occlusion, position of all 8 arms were confirmed by 3D imaging in 12/15 cases. Protruded arms and dynamic change in the size of residual defects were clearly visualized by 3D imaging. 3D echo during the procedure defined the mechanisms by which arm protrusion occurred.

Conclusions: Current 3D reconstruction provides clinically relevant information in the selection and monitoring of patients undergoing ASD device occlusion. Information obtained by this technique can improve the understanding of the mechanism of device deployment and defect closure.

1231-121 Three-dimensional Transesophageal Echocardiographic Assessment of Left and Right Ventricular Outflow Tract in Pediatric Congenital Heart Disease

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Purpose: preoperative assessment with three-dimensional transesophageal echocardiography (3D-TEE) of stenosis (ST) at sub-valvular and supra-valvular level of the left (LVOT) and right (RVOT) ventricular outflow tract.

Methods: 3D-TEE was performed just before surgery in 10 children (ages 5–12 years) with a miniaturized pediatric transesophageal multiplane probe. Data were acquired using rotational scanning at 2 degrees interval with ECG and respiratory gating. The outflow tract was reconstructed in longitudinal and horizontal (above and below the aortic or pulmonary valves) cross-sections with anyplane and volume rendering display. The extension of the lesion, the relationship with the valves and the nature of the ST were assessed. 3D dynamic reconstructions were validated by surgical findings.

Results: 3D reconstructions were adequate in 9/10 pts; in 1 pt 3D reconstruction failed, due to inadequate gain setting. Among LVOT lesions, we could define 2 sub-aortic discrete and fibrotic ST, 1 sub-aortic circular membrane and 1 supra-aortic fibrous ring. Among the RVOT lesions there were 1 fibrotic discrete sub-pulmonary ST, 2 muscular and 2 fibromuscular ST. In 2 pts the extension of the obstructing tissue to the mitral valve could be clearly seen from a horizontal cross-section as looking from the left ventricle. In 2 pts 3D images gave additional information, identifying in 1 a double chamber right ventricle and in the other one the close relation of the supra-aortic ring with one aortic cusp. One suprapulmonary ST was not displayed, due to scarce resolution. The anatomy of the 3D reconstructions was confirmed by surgery.

Conclusions: 3D-TEE allows adequate assessment of both outflow tracts. Particularly helpful are horizontal cross-sections from above and below, which allow a definition of the degree and extension of the lesion.

1231-122 Dynamic Morphology of Secundum Atrial Septal Defect Evaluated by 3-Dimensional Echocardiography

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Background: Dynamic changes in morphology of the secundum ASD is an important component of its physiology and has implications for various treatment modalities. The purpose of this study was to evaluate, by three-dimensional (3-D) echocardiography, the contraction pattern of secundum ASD's through the cardiac cycle, and potential determinants.

Methods: In 25 patients with an isolated defect (median age 8.6 yrs), 3D echo data were acquired using the Hewlett-Packard software and multiplane transesophageal probe. 3-D images, assessed from the RA, were reconstructed using the TomTec system. In 7 patients the presence of a thin atrial septum or multiple defects precluded clear delineation of the defect margins and were therefore excluded. In 18 cases, ASD area, long and short axis dimensions, and the distance of the deficient anterior rim were measured in end-atrial diastole and systole. Oval shaped defects (n = 10) were classified into 2 groups according to the angle between the defect long-axis and the aorta; either parallel (angle < 45) or perpendicular (> 45).

Results: ASD area significantly changed throughout the cardiac cycle (mean 63.7%, $p < 0.001$), ranging from 31% to 86%. The defect contracted symmetrically and independent of the angle to the aorta. The size of the oval shaped defects parallel to the aorta changed more than those perpendicular ($p < 0.01$). Circular shaped defects changed size variably. The presence of aneurysmal deformation of the atrial septum did not influence the percentage of shortening. In all cases (10) with a deficient anterior rim, the distance of absent rim was significantly reduced ($p = 0.01$) during atrial contraction.

Conclusions: Dynamic changes of the secundum ASD appear influenced by its morphology and location. This information can be relevant in improving our understanding of the pathophysiology of atrial shunting, and its potential impact on device occlusion.

1231-123 Evaluation of Ventricular Outflow Tract Abnormalities Using Real-time Three-dimensional Echocardiography

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Background: On the hypothesis that real-time 3D (RT3D) echo can provide unique views of structural anatomy over standard 2D echo, we evaluated 25 pts with known ventricular outflow tract anomalies.

Methods: Pts (ages 3 d–15 yrs with weights 2.5–53 kgs) were scanned without sedation from the parasternal, apical, and sub-costal windows. The Duke RT3D system uses a matrix phased array transducer (2.5–5.1 MHz) to scan a 65° pyramidal volume at 22 vol/s with an image display of standard B scan sectors and inclined scan planes that can be oriented throughout space. Up to 3 s of moving volumetric data was acquired in real-time and stored for off-line analysis to display any combination of planes or to perform volume rendering on a computer workstation.

Results: RT3D demonstrated abnormalities of LV and/or RV outflow in all 25 pts with the following diagnoses: subaortic stenosis, aortic stenosis/atresia, pulmonic stenosis/atresia, TOF, DORV, D-TGA, L-TGA, and AP window. Inclined and intersecting scan planes enabled unique visualization of 1) conal septum in relation to VSD in TOF and DORV, 2) en-face views of the defect in AP window and in the Norwood anatomosis in aortic atresia, 3) great vessel relationships at multiple levels in D-TGA and L-TGA, and 4) type and degree of obstruction in aortic and pulmonary stenosis/atresia.

Conclusion: RT3D echo can identify ventricular outflow tract abnormalities. The ability to incline scans and perform volume rendering permits novel visualization of various complex structural abnormalities of ventricular outflow.

1231-124 Transthoracic Approach of 3D/4D Echocardiography in Congenital Heart Disease

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Background: The 3D/4D reconstructed images of intracardiac structures in congenital heart diseases could be obtained by the transthoracic approach in pediatric age.

Method: The 90 serial 2D images were obtained at every 2 degrees (gated by respiration and ECG) by the rotational scanning from either subxyphoid or parasternal approach, using rotational deveice. From these images, 3D images were reconstructed by Tomtec Echoscanafter setting the proper cutplanes. The study subjects were 93 cases with various congenital heart diseases. The age ranged from 3days to 11 years old. The BSA ranged from 0.16 to 1.48 m^2.

Result: Of 93 cases, 309 3D/4D reconstructions were attempted. 3D/4D images were obtained from 78 cases out of 93 cases (8%). In cases with BSA beyond 1.0 m^2, 3D/4D images could not be obtained because of poor penetration. Among the 309 reconstructed 3D/4D images, 123 images (30%) were evaluated as clinically useful to assess intracardiac anomalies. The round shaped ostium primum defects wre shown in 8 out of 11 cases (73%) with atrioventricular canal defect (AVCD) in the anterior aspect.

The finding of unwedge position of the aorta between right and left atrioventricular orifices was clearly seen in the cases with AVCD in the cranial aspect of atrioventricular valves. In a case with tetralogy of Fallot, aortic overriding was clearly seen in the anterior aspect of the right ventricle.

Tetralogy of Fallot

Conclusion: 3D/4D with good image quality could be obtained by the transthoracic approach in newborn and infant.

1232 Echocardiographic Quantitation of Flow Parameters

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1232-137 A Digital Three-dimensional Color Doppler Velocity Reconstruction Study of the Relationship Between Orifice Shape and Flow Convergence Geometry: In Vitro Experiments

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Introduction: The proximal flow convergence method (FC) is most often employed with an assumption that a hemispherical iso-velocity surface exists for most orifices.

Methods: We derived 3D digital color Doppler data in an in vitro pulsatile flow model. Digital velocity data (prior to color assignment) from circular, rectangular, and triangular shaped orifices all of area 0.24 cm^2 were acquired at 9 flow rates (40–120 ml/sec) with an ATL HDI-3000 ultrasound system controlling rotation of a 7.4 MHZ multiplane probe. Our digital 3D method allowed velocity vector reconstructions such that various Doppler iso-velocities could be chosen, and the resulting 3D FC surfaces defined. We measured the lengths of the major and minor axis of the FC iso-velocity surface in 3D space to examine eccentricity and computed 3D surface area directly by adding FC arc lengths.

Results: The rectangular orifice produced greatest eccentricity indexes (0.85 ± 0.05, $p < 0.001$ versus circular and triangular orifices), while circular and triangular orifices yielded similar values (0.68 ± 0.07 and 0.63 ± 0.06, p = NS). The 3D derived FC flow rates correlated quite well with the actual flow rates (r = 0.82, 0.83 and 0.87 for circular, rectangular and triangular orifices, respectively).

Conclusion: The digital 3D Doppler method we developed allows post acquisition choice of directly measurable 3D iso-velocity surfaces yielding robust and accurate FC flow rate computations.

1232-138 Advantages of a Digital Color Doppler Method for Computing Flow in Highly Pulsatile Vessels

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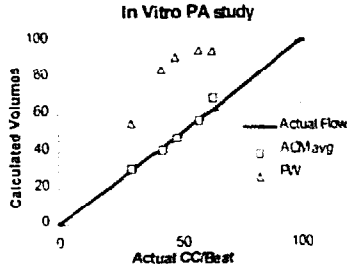
Background: The aim of this study was to determine the accuracy of digital color Doppler calculation (ACM) for determining regional flows in highly pulsatile vessels and also compare it with the conventional Pulsed Wave (PW) Doppler flow calculation method.

Methods: In a flexible, distensible pulsatile Pulmonary Artery (PA) flow model, we measured the volume flow from digital color) Doppler images with a Toshiba PowerVision (ACM), at 0°, 45°, and 90° axes across the elliptical cross of the "PA", which varied in shape as well as in diameter (50% variation) with the cardiac cycle.

Results: Over 45 flows with a range of volumes from 28 cc to 63 cc/beat. The ACM method proved to be substantially more accurate than the PW method (Fig.). ACM computes changes flow area and flow for profiles automatically; also, it's rapidity and ease of use allowed us to calculate and average the flows on the different crossectional vessel axes.



Conclusion: In highly pulsatile great arteries the ACM method should have distinct advantages over the PW method.