Preoperative Assessment Using 3-D Models Improves Surgical Planning for Patients with Complex Congenital Cardiac Defects

Authors: Matthew Bramlet, Randall Fortuna, Karle Welke, Children's Hospital of Illinois, Peoria, IL

Abstract:
Introduction: Assessment of complex congenital cardiac anatomy is currently limited to 2-D assessment. The use of 3-D cardiac models may allow for previously unavailable visualization and analysis of anatomy. We describe the cost-effective, readily reproducible use of basic 3-D printing of cardiac structures to provide a new dimension in complex congenital heart anatomy assessment.

Hypothesis: Three-dimensional models of patient specific congenital heart disease improve surgical planning for complex intra-cardiac repairs.

Methods: Three patients were selected with complex spatial orientation surgical problems; 2 with double outlet right ventricle pulmonary atresia with remote ventricular septal defect (VSD), and 1 with a left ventricular aneurysm near the base of the heart. A detailed mask was applied to the DICOM image sets which focused on myocardial detail rather than blood pool (2 MRI, 1 CT) to generate the 3-D rendered model. The model consisted of 3 components in a short axis orientation; a basal portion, a middle slice containing all four valves, and an apical portion. This method allows for easy tactile manipulation of a low cost plaster composite material.

Results: Each model afforded additional key information not available from traditional imaging which influenced the surgical approach for each patient. In the first case, the 3-D model revealed a Swiss-cheese type VSD defect that was not appreciated on other imaging modalities (including pre-op TEE), (FIGURE) this shorted the cross-clamp time. In the second case, the 3-D model changed the surgical plan from a single ventricle repair to a two ventricle repair. In the third case, the 3-D model illustrated the relationship between the aneurysm and the left coronary artery influencing the surgeon to revert to an intracardiac approach.

Conclusions: Low cost, solid opaque cardiac models with intricate intracardiac details improve surgical planning in complex congenital heart disease.