Congenital heart disease and rapid cardiac prototyping

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Objectives

• Review literature on 3D cardiac printing
• Describe 3D printing workflow
• Discuss clinical applications
Rapid Prototyping: A New Tool in Understanding and Treating Structural Heart Disease

Michael S. Kim, Adam R. Hansgen, Onno Wink, Robert A. Quaife and John D. Carroll

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To help solve challenging cardiac problems, doctors at Children’s press ‘print’

3-D printer saves toddler struggling to breathe
Scope of the clinical problem

- Congenital heart defects most common human birth defect; 1-2% population; Common
- Wide variety of defects with wide range of severity
- Clinical decisions largely made based on appearance of heart on imaging Structural information necessary
- Care of the patient with congenital heart disease involves Individualized, specialized care
  - Exquisite 3D cardiac imaging
  - Frequently require a procedure to perform repair/palliation
  - Expert post-operative cardiac intensive care unit care
Rapid Cardiac Prototyping - 2014

• 3D printers more accurate, affordable
• 3D segmentation software allows for complex segmentation shapes
• High-quality Pediatric cardiac 3D imaging
  – Cardiac CT
  – Cardiac MRI
  – 3D Echocardiogram
3D segmentation (CT)
3D segmentation (MRI)
3D Echo
3D segmentation (echo)
Clinical Impact
Case 1

- D-TGA S/P Mustard
- Pulmonary venous baffle obstruction
Letter to the Editor

3D heart model guides complex stent angioplasty of pulmonary venous baffle obstruction in a Mustard repair of D-TGA

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Case 2

- Post-myocardial infarction ventricular septal defect
- Severe congestive heart failure
Case 4

• Cc-TGA with pulmonary stenosis S/P double switch
• Severe systemic venous baffle obstruction
Case 3
Case 4: 3D Printed Model for Guiding Conjoined Twin Separation Surgery

It takes a village...

Clinical Team:
- Pranava Sinha, MD,
- Michael Boyajian, MD,
- Dorothy Bulas, MD,

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3D printing/engineering Team:
- Carolyn T Cochenour, BBME,
- Axel Krieger, PhD
Education

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• Patient-specific team simulation/education
• Pediatric resident education series on VSD, Tetralogy of Fallot
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Case 3

- Double outlet right ventricle with anterior and leftward aorta, bilateral conus
- Two well-formed ventricles
- Single v vs. switch and VSD closure?
Anterior Surface