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3D Modeling of Pediatric Hearts with Congenital Defects

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College of Engineering
Mechanical and Nuclear Engineering

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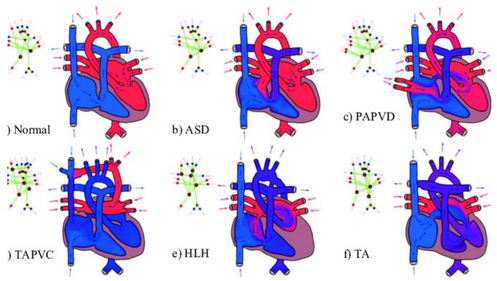
ETM3 Engineered Tissue Multiscale Mechanics & Modeling

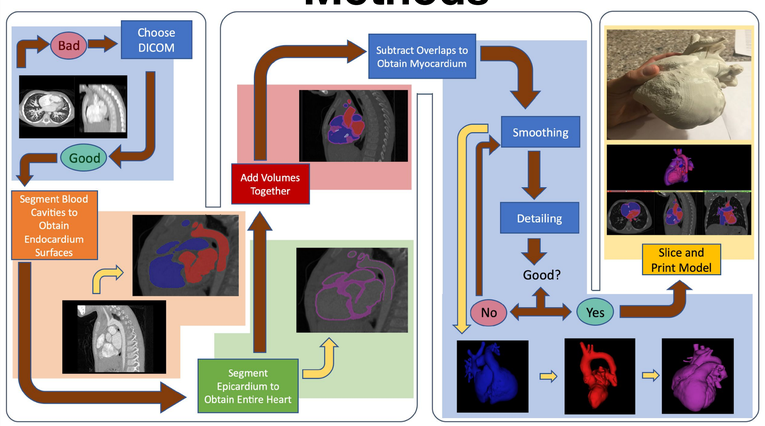
Research Objectives

Goal: The creation of 3D printed heart models can improve surgical understanding of the complexity and variability of congenital heart disease (CHD).
Hypothesis: 3D printed models improve preoperative planning and shared team understanding.



Challenge 1: CHD requires 3D-visualization in between specialists involved in surgical planning.
Challenge 2: CT and MRI scans performed on patients are done with the intent of 2D visualization and not 3D models.
Challenge 3: Exact replicas with multiple colors for extended visualization are very expensive.

Methods

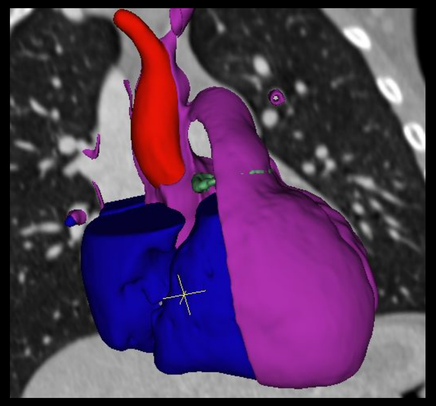


▪ CT and MRI ▪ 3D Slicer ▪ Segmentations and Editing ▪ 3D Printing ▪ Presentations

Datasets and Surveys

Ovine Heart
- Experimented with the capabilities of 3D Slicer
- Thresholded the muscle and printed the heart in four separate segments

Sinus venosus ASD with Pulmonary Anomaly
- Segmentations must capture all landmarks necessary for orientation
- Myocardium was created, sliced, and printed



Survey from Pediatric Cardiology Conference
- Highlights the benefits of creating anatomically identical models
- Confirms the need to continue exploring this technology

D-transposition of the great arteries with an arterial switch
- Showcased the ability to work with MRI datasets
- Used a Matlab code to import MRI series in 3D Slicer
- Combined two different datasets into one complete

1. How well do you currently understand the anatomy and physiology of complex congenital heart disease?

Novice		Competent		Expert
1	5	5	1	3

2. Do you feel that after the surgical conference has been concluded, you have a better understanding of congenital heart disease and the surgical procedures involved in correction?

No		Indifferent		Yes
		2	4	9

3. Do you feel that after being provided with the 3D printed cardiac model, you now have gained a better understanding of congenital heart disease and the surgical procedures involved un correction?

No		Indifferent		Yes
		1	2	12

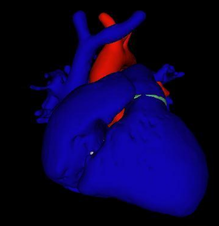
4. Did the 3D printed cardiac model accurately represent the images which were presented?

No		Indifferent		Yes
			2	13

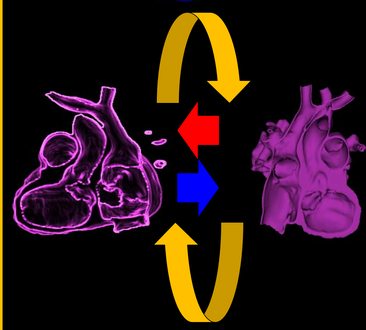
5. Do you feel that 3D printed cardiac models should be provided for every complex congenital heart disease patient?

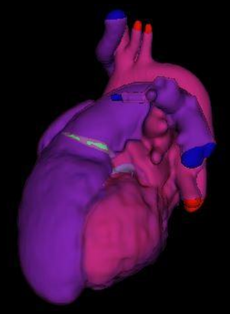
No		Indifferent		Yes
			3	12

Preliminary results



Computer Generated Models
- Allows multiple segmentations
  - Incorporation of valves, blood cavities, and myocardium
- Can be sliced to show any orientation





Physical 3D Models
- Confirms feasibility of the transformation from DICOM to model
- Allows surgeon to hold the heart that is being operated on
- Improves understanding of 3D-anatomy

Future Directions

- Improve the automation and speed at which models can be created
- Print using flexible materials so that cuts can be made into the models
- Further Investigations:
  - Computer simulations created by mesh analysis
  - Implementation of 4D flow analysis

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