Computational Fluid Modelling for Surgical Planning of Single Ventricle Congenital Heart Defects

Presented by: Vishnu Emani
Mentors: Dr. David Hoganson, Dr. Vijay Govindarajan
Introduction

• Single Ventricle Defects (SVD)
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• Fontan: Single or Bilateral SVC
Introduction – Hepatic Flow Distribution

- Venous flow from liver
- Important to be well distributed
- Pulmonary Arteriovenous Malformations (PAVMS) (Srivastava et al.)
Introduction – Computational Fluid Dynamics

• Very difficult for surgeons to predict
  • Anatomical variations
• Computational Fluid Dynamics (CFD)
  1. CAD model
  2. Apply boundary conditions
  3. Processing
  4. Post-Processing
Purpose

Make custom scripts to speed post-processing

Evaluate effects of various parameters on Hepatic Flow Distribution
Methods – Custom Scripts

• Compute power loss, flow distributions, etc.
• Tecplot macros
• GUI

• Post-processing reduced by 2 hours
Methods – Idealized Geometry

• Reason: isolate variables
• Measurements from patient imaging for realistic sizes
• Fusion 360 CAD
• Assume cylindrical, uniform diameter
• Vary factors in series: Fontan curvature, vascular diameters, and fontan positioning
Methods – CFD

• Assumptions: Incompressible, Laminar, No-slip, Newtonian Viscosity
• Fluent® Solver
• Flow Boundary Conditions varied
  • Ratio between SVC to IVC flow
• Hepatic flow considered 25% of total flow
Results

• Fontan curvature series

% Flow to LPA with varying curvature

- SVC:IVC = 1:1
- SVC:IVC = 1:1.5
Limitations

• Idealized geometries may not be fully accurate
• Rigid wall assumption
• Steady flow assumption
Next Steps

1. Finish running simulations on Fontan positioning, SVC diameter

2. Perform virtual surgery using significant parameters
References