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

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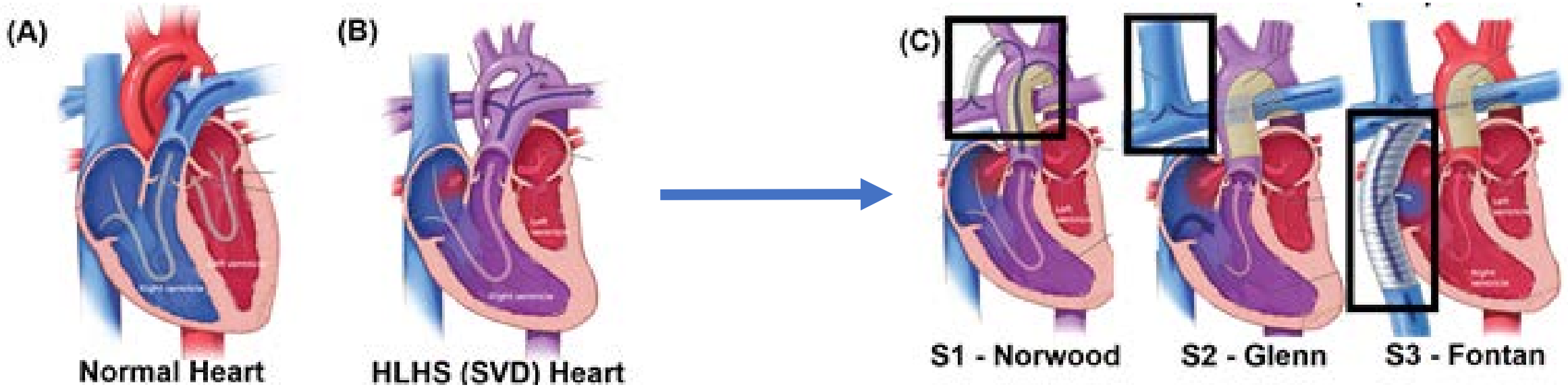
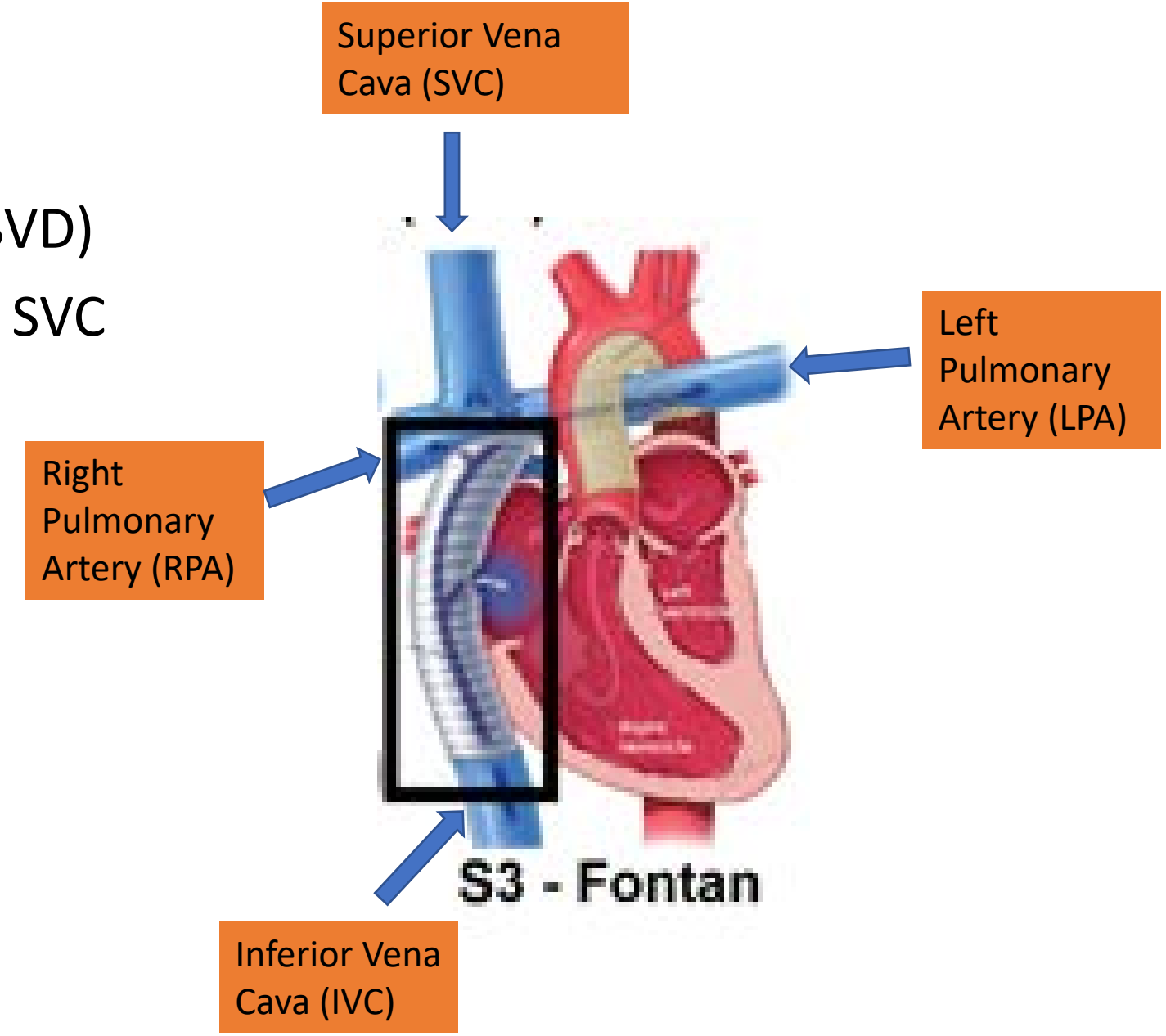
Introduction

- Single Ventricle Defects (SVD)



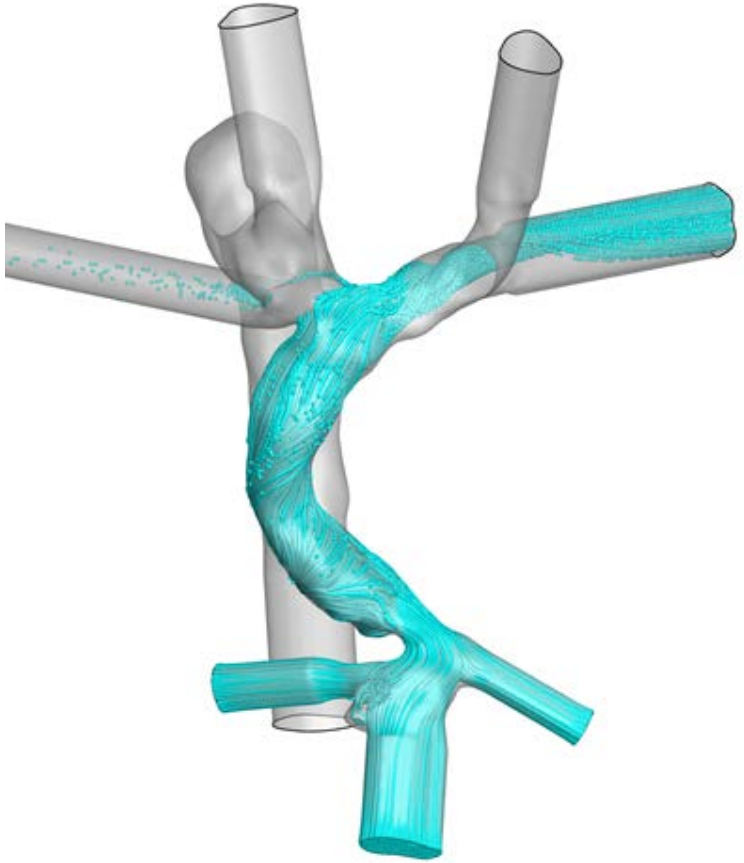
Introduction

- Single Ventricle Defects (SVD)
- Fontan: Single or Bilateral SVC



Introduction – Hepatic Flow Distribution

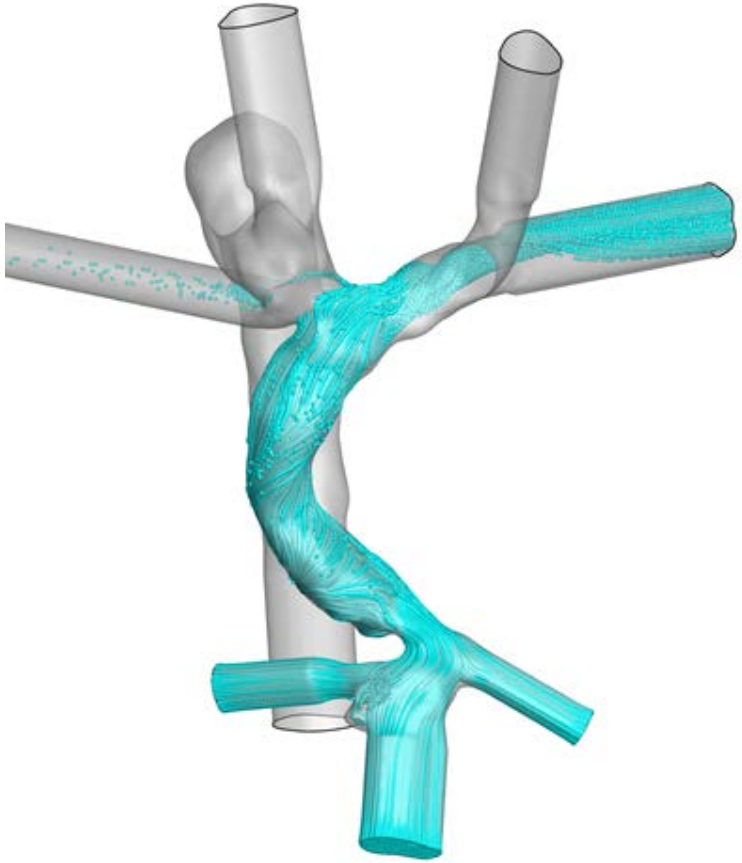
- Venous flow from liver
- Important to be well distributed
- Pulmonary Arteriovenous Malformations (PAVMS) (Srivastava et al.)



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

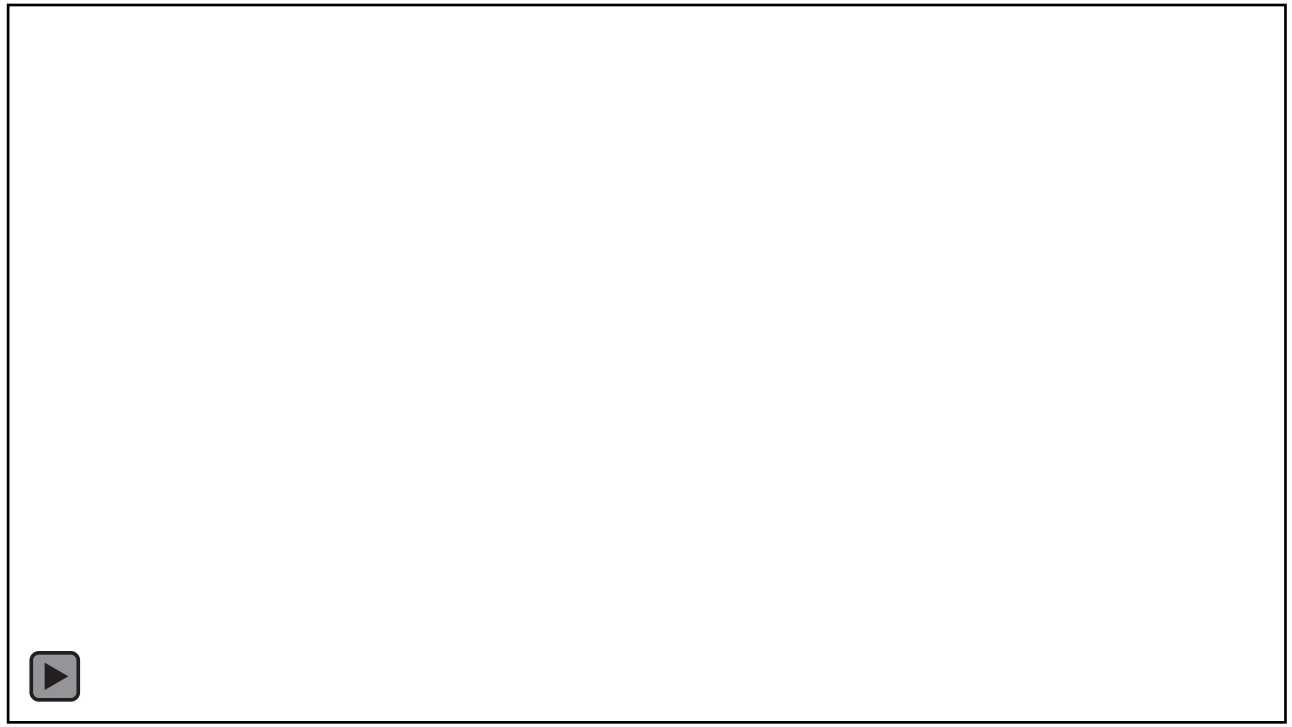
Make custom scripts to speed post-processing

Evaluate effects of various parameters on Hepatic Flow Distribution

Methods – Custom Scripts

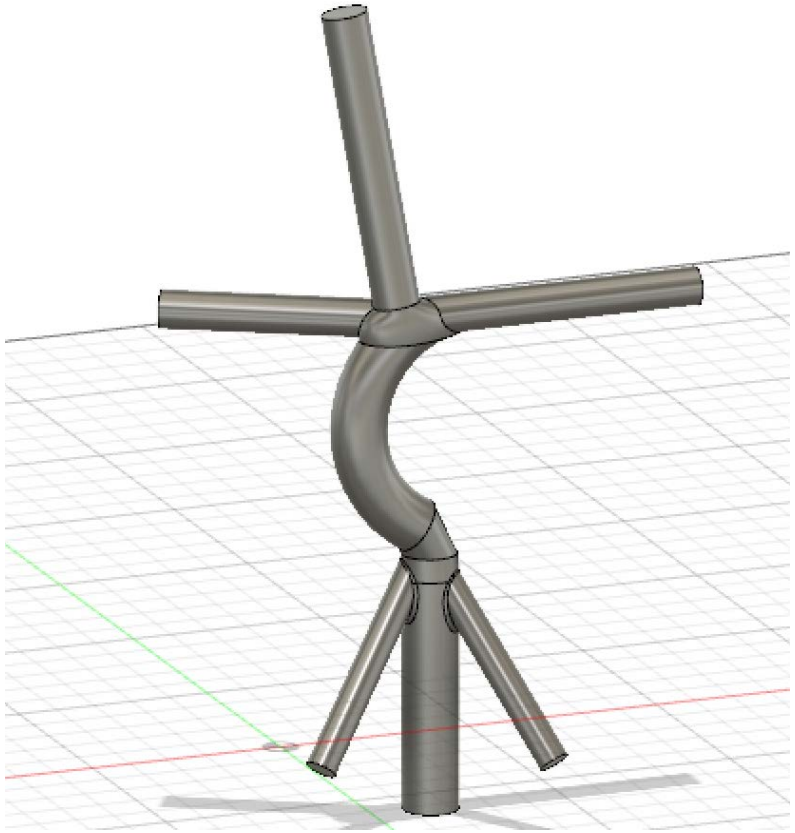
- Compute power loss, flow distributions, etc.
- Tecplot macros
- GUI

- Post-processing reduced by 2 hours



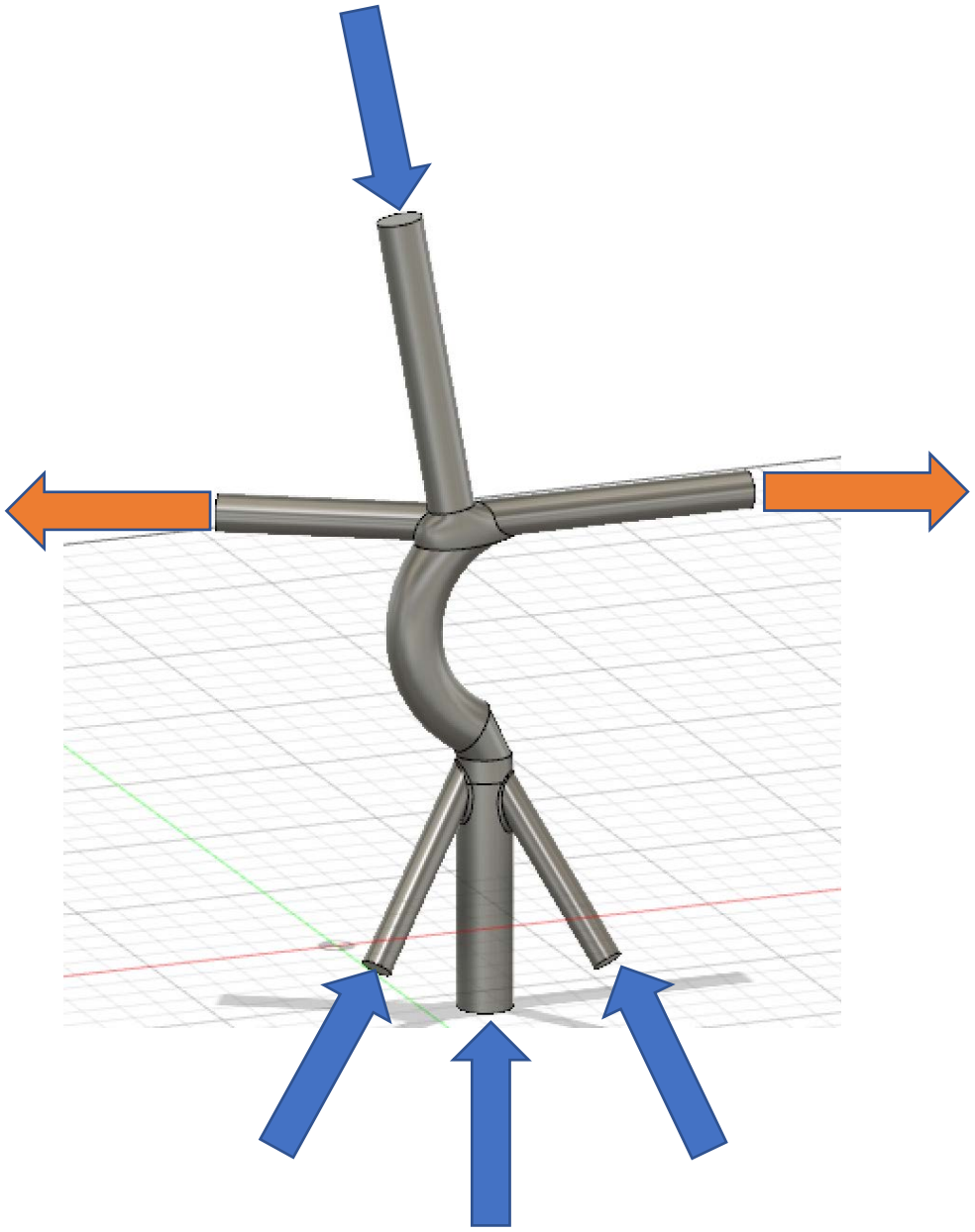
Methods – Idealized Geometry

- 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



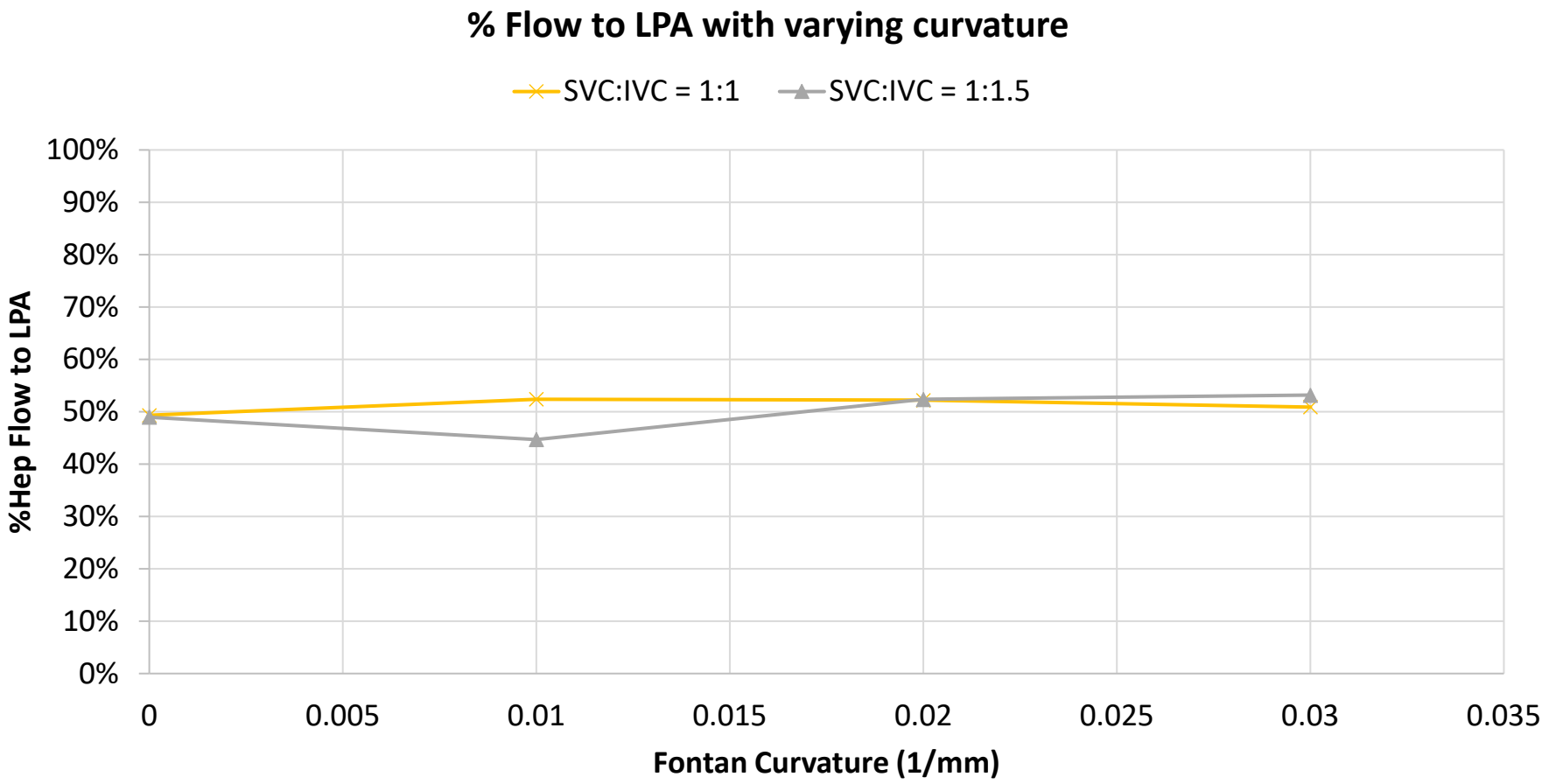
Methods – CFD

- 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



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

- Srivastava, D., Preminger, T., Lock, J.E., Mandell, V., Keane, J.F., Mayer Jr, J.E., Kozakewich, H. and Spevak, P.J., 1995. Hepatic venous blood and the development of pulmonary arteriovenous malformations in congenital heart disease. *Circulation*, *92*(5), pp.1217-1222.