

Characterizing Hemodynamics of Soft Prosthetic Venous Valves for Caval Valve Implantation

Bryce F. Starr, Caglar Ozturk Ph.D., Markus Horvath Ph.D., Mulan Jiang, Ellen T. Roche Ph.D.
 Therapeutic Technology and Device Development Laboratory, Massachusetts Institute of Technology

Rationale

- There is relative incoherence amongst the parameterization of venous valve dynamics
- Soft-leaflet caval valves may be useful in treating a variety of cardiovascular conditions:
 - Implantation of caval valves was attempted in patients with severe tricuspid regurgitation¹
 - Single-Ventricle Physiology modelling suggests caval valve placement may be clinically useful in improving cardiac return, reducing retrograde flow, increasing pulmonary pressures, and lowering hepatic pressures²
- Rigid, mechanical valves and soft-leaflet cardiac valves are not optimized for the complex and unique hemodynamic environments of the caval vasculature in pathological states

Methods

Generate: Leaflet profile and 3D attachment geometry with projections onto conical or ellipsoid silhouettes

Model: Flow and leaflet deformation with fully coupled Fluid-Structure Interaction analysis

Vary: geometric orifice area (GOA), number of leaflets and total leaflet height

Validate: with leaflet motion with mechanical valve *in vitro*

Evaluate: performance using coaptation geometry, opening/closing times, thrombosis potential, wall stress, leaflet strain and flow velocity

Manufacture: optimal valve with 3D printed frame, 6-0 prolene, and .1 mm ePTFE

Generate:



Vary:

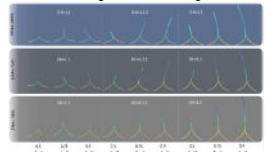


Results

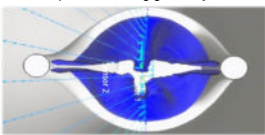
1 Leaflet geometries vary stress and Endothelial Cell Activation Potential (ECAP) for the same flow waveform



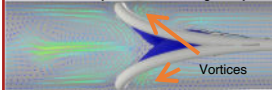
3 Coaptation length changes with GOA, Diameter:Height ratio and Height alone



4 Computational simulations and fully-coupled Fluid Structure Interaction predicts closing geometry



2 Soft leaflet closure *in silico* shows vortices may reduce thrombogenicity



5 Open and closed geometries of soft bileaflet (a, b) soft trileaflet (c, d)

