A Computational Patient-Specific Model of Impella Support for Cardiogenic Shock

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Background & Objectives

- Up to 15% of myocardial infarction patients also suffering from cardiogenic shock [1]
- Percutaneous ventricular assist devices (PVAD) such as the Impella increasingly provide circulatory support
- Due to limited understanding of Impella performance; objective of present study is to explore hemodynamics of Impella

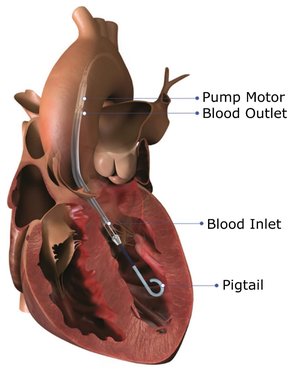

Figure 1: Impella device implanted within the left ventricle

Methods: Computational Model

- Patient-specific geometry of the aorta [1]
- Dynamic boundary conditions & scaled inlet wave form [2]
- Polyhedral computational grid to reduce computational cost

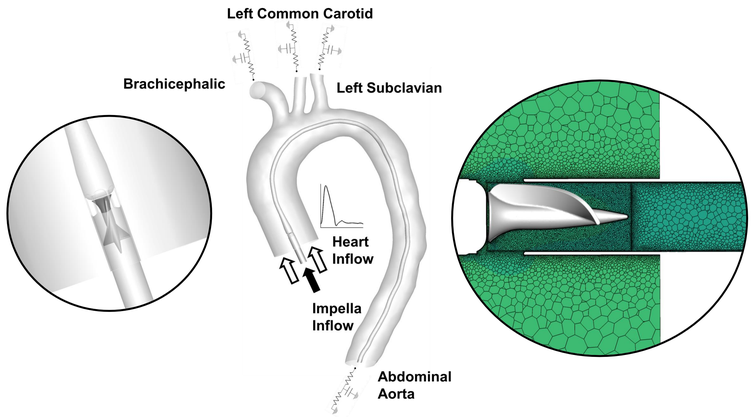

Figure 2: Digitalized model with boundary conditions and computational grid

Methods: Study Design

- Baseline (Impella is off)
- Scenario 1 (S1) and Scenario 2 (S2) with 30% and 70% of Impella contribution to the total perfusion of 5 L/min

Table 1: Working conditions in studied scenarios

Model	P-Level	rpm	Impella Q (L/min)	LV Q (L/min)
Baseline	P-0	0	0.0	5
S1	P-3	33,000	1.5	3.5
S2	P-9	46,000	3.5	1.5

Results: Flow Structure

- Complex vortex structures and significantly increased velocity observed at the site of Impella jet exit [1]
- Turbulence and vorticities more dominant as Impella flow rises

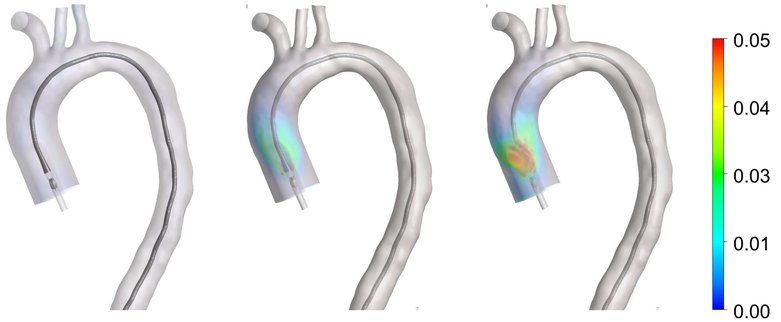

Figure 3: Turbulent kinetic energy distribution at peak systole

Results: Shear Metrics

- Increased share of Impella rises local wall shear stress within the reported range of other circulatory support systems [1]

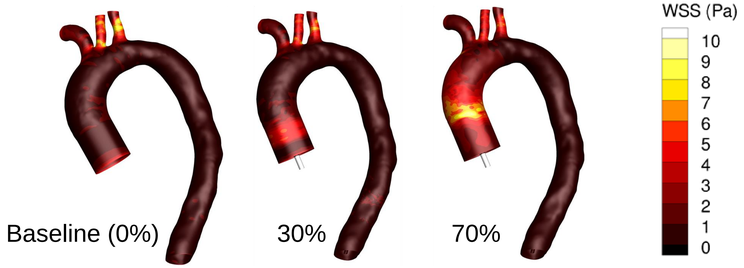

Figure 4: Wall shear stress distribution at peak systole

Discussions & Conclusions

- Higher vorticity & turbulent energy with increasing PVAD support
- End-organ perfusion maintained in all scenarios even with less-pulsatile flow (i. e. increased Impella contribution) [1]
- Unique utility of computational models to quantify flow and perfusion patterns
- Promising potential of computational approaches for mechanistic understanding & risk stratification of mechanical support therapies

References

[1] FR. Nezami et al., "A Computational Fluid Dynamics Study of the Extracorporeal Membrane Oxygenation-Failing Heart Circulation". ASAIO J. 2021 Mar 1;67(3):276-283.

[2] FR. Nezami et al., "Hemodynamics of Impella Support: A Computational Patient-specific Model Of Therapy For Cardiogenic Shock", 66th ASAIO Annual Conference 2021

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