A Left Ventricular Assist Device (LVAD), is a mechanical pump capable of providing circulatory support when used as bridge-to-transplantation for patients with failing hearts awaiting a transplant, with the additional benefit of allowing for cardiac recovery when used as destination therapy. The newer generations of continuous flow VADs are essentially axial or radial flow pumps. The most devastating complication of VAD therapy is caused by embolization of thrombi formed within the LVAD or inside the heart into the brain leading to stroke. Anticoagulation management and improved LVADs design has reduced stroke incidence, however, investigators have recently reported the incidence of thromboembolic cerebral events is still significant and ranges from 14% to 47% over a period of 6-12 months. The hypothesis that incidence of stroke can be significantly reduced by adjusting the VAD outflow cannula implantation to direct dislodged thrombi away from the cerebral vessels has been recently supported by a series of steady flow computations assuming rigid vessel walls for the vasculature. Such studies have shown as much as a 50% reduction in embolization rates depending on outflow cannula implantation.

In this dissertation, a pulsatile hemodynamics model with compliant vessel walls is developed to further establish this hypothesis. A time-dependent multi-scale Eulerian Computational Fluid Dynamics (CFD) analysis of patient-specific geometry models of the VAD-bed vasculature is coupled with a 3D Finite Element Method (FEM) model for the mechanical response of the vascular walls to establish the VAD assisted hemodynamics. A Lagrangian particle tracking algorithm is used to determine the embolization rates of thrombi emanating from the cannula. This multiscale Eulerian-Lagrangian pulsatile fluid-structure coupled paradigm allows for a fully realistic model of the hemodynamics of interest.

Results are presented for a simple vessel model of the ascending aorta to validate the anisotropic fiber orientation implementation. Arterial wall dilation is measured between 5-20% in the range reported in literature. Hemodynamics of the VAD assisted flow in a patient-derived geometry computed using rigid vessels walls are compared to those from linearly elastic and a hyperelastic anisotropic vessel wall models. Moreover, the thromboembolization rates are presented and compared for pulsatile hemodynamics in rigid and compliant wall models. Pulsatile flow solutions for embolization probabilities corroborate the hypothesis that tailoring the LVAD cannula implantation configuration can significantly reduce thromboembolization rates, and this further corroborates previous steady-flow calculations.

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The public is welcome to attend.