A Multi-Scale CFD Analysis of Patient Specific Geometries for Different LVAD Implantation Configurations Under Pulsatile Flow Conditions: An Investigation into Thrombo-Embolism Formation to Reduce Stroke Risk

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ABSTRACT

A Left Ventricular Assist Device (LVAD) is a mechanical pump that provides temporary circulatory support when used as bridge-to-transplantation and relieves workload demand placed on a failing heart allowing for myocardia recovery when used as destination therapy. We employed a multi-scale model of the aortic circulation in order to examine the effects on flow conditions of the cannula implantation at different angles on a patient specific geometry obtained from CT scans, which may alter the flow pattern of potential thrombi downstream either increasing or reducing the chances of stroke. Investigated angle configurations include the pump inlet cannula at 30°, 60° and 90° to the right lateral wall of the ascending aorta. We also considered two placements of the VAD cannula along the ascending aorta. We implemented a Lagrangian particle-tracking scheme to quantify the amount of stroke-inducing particles at each outlet and included flow visualization through streamlines to identify regions of strong vorticity and flow stagnation, which can promote thrombus formation. Thrombi were modeled as spheres with perfectly elastic interactions numerically released randomly in time and space at cannula inlet plane, and based on medical surveys several particle diameters were studied: 2.0mm, 3.0mm and 5.0mm. Preliminary pulsatile flow results for aforementioned angles suggest: (1) a 90° cannula implementation causes flow impingement on the left lateral aortic wall and appears to be highly thrombogenic due to large momentum losses and (2) shallow and intermediate cannula angles promote regular flow carrying particles towards the lower body potentially reducing stroke risk. We will present detailed results from thrombus particle release multi-scale CFD studies accompanied with statistical analysis of the significance of stroke risk reduction under various implantation scenarios.

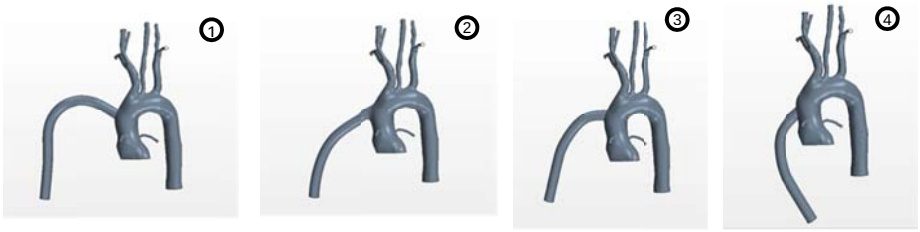

Figure: Cannula configurations (1) perpendicular (90°), (2) shallow (30°), (3) intermediate shift up and (4) intermediate shift down (60°).