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FINITE ELEMENT SIMULATION OF A HUMAN LEFT VENTRICLE WITH IMPLANTED VENTRICULAR ASSIST DEVICE

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Left ventricular assist devices (LVADs) play an important role helping patients suffering from heart diseases, as they are primarily used as a bridge to transplant technology [1]. We examine the interaction between blood flow in the left ventricle, LVAD, and the cannula inserted into the ventricle. We have determined stagnation and low velocity areas by solving transport equations for residence time and Virtual Ink in the ventricle under different operational conditions of the LVAD. Such areas of stagnation and low velocity are prone to thrombosis.

From a computational mechanics perspective, defining appropriate boundary conditions plays a vital role in this project for the structural and fluid mechanics part, respectively. In our current work, we make use of a simplified geometry with prescribed displacements of the ventricular wall based on the inflow into the left ventricle [2]. The fluid boundary conditions at the valves, which are modeled as simplified planes, progress from simple constant boundary conditions to resistance boundary conditions, which resemble the circulation in the blood vessels and the constant flow through the LVAD whose cannula is inserted at the apex of the ventricle. Eventually, we are looking for a closed loop formulation of the body circulation. The interaction between ventricle wall and fluid is imposed by the wall movement. The LVAD's pump flux is set as a time-dependent Dirichlet boundary condition.

For the different stages of the simulations, an in-house-code [3] is used. It uses a stabilized finite element method to discretize time and space. The fluid is subject to the incompressible Navier-Stokes equations with a Newtonian material law. The stagnation time as a key result of the simulations is obtained by coupling a transport equation for the residence time to the fluid equations.

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