FSI in a Beating Human Heart Model

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ABSTRACT

Investigation of blood flow and cardiac/vascular tissue mechanics in a living human heart model is to be presented. Interaction of blood with heart muscles is a strong fluid-structure interaction (FSI) phenomenon. Two-way coupling approach between Abaqus (calculates motion and deformation of heart geometry) and FlowVision (calculates viscous blood flow in heart) are used to simulate this complex phenomenon. The simulations are conducted in 3 different stages with increasing complexity of simulation: (1) one-way coupling approach with artificial mechanical valve motions and time-dependent boundary conditions, (2) two-way coupling approach with fluid controlled heart and mechanical valve motions, (3) two-way coupling approach with fluid controlled heart and tissue valve motions.

SIMULIA Living Heart Human Model (LHHM) is a dynamic, anatomically realistic, 4-chamber heart model having 2 mechanical valves which couples the electrical and mechanical fields acting during heartbeat. Their synchronous actions regulate the heart filling, ejection, and overall pump functions. FlowVision is a finite-volume CFD code focused on realistic calculations of advanced multi-physics problems especially through strongly coupled FSI co-simulations with Abaqus.

Originally, LHHM comes with a 1D fluid network model, only capable of simulating the dynamic pressure/volume changes of the intra and extra-cardiac circulation network model. In this work, a full 3D blood circulation is numerically modeled with FlowVision providing a very detailed spatial and temporal resolution for modeling the cardiac hemodynamics. The obtained results are presented in comparison with literature findings and yield a good agreement with the experiments..