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Hemodynamics and flow-vessel interaction in patient-specific aorta using unified lattice Boltzmann computation and simulation

HUIDAN (WHITNEY) YU, Indiana University-Purdue University, Indianapolis (IUPUI), ZHIQIANG WANG, YE ZHAO, Kent State University, SHAWN D. TEAGUE, Indiana University — Patient-specific blood flow simulation is mainly relying on the utilization of commercial software. Geometrical simplification and approximation are usually made thus weaken the capability to aid clinical diagnose and assessment. We develop a unified computing platform to simulate patient-specific hemodynamics and flow-vessel interaction using lattice Boltzmann method (LBM), which tightly integrates anatomical-structure extraction from imaging data and numerical simulation in one computation mesh structure, where the LBM solves level set equation for image segmentation and Navier-Stokes equation for fluid dynamics respectively. The patient-specific vessel geometry, volumetric ratio of solid versus fluid, and the orientation of the boundary obtained with high accuracy seamlessly feed to the numerical simulation needs. In order to better treat the complex geometry, we specifically develop volumetric lattice Boltzmann scheme which strictly satisfies mass conservation when boundary moves. Validation study is on hemodynamics and flow-vessel interaction in healthy and diseased aortas. Flow rate and structure, pressure and vorticity distribution, as well as wall normal and shear stresses, are revealed in both cases.

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