Simulation of blood flow in a compliant vessel by the immersed boundary method

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Abstract. We develop a computational approach to analyze hemodynamics in the aorta; this may serve as a useful tool in the development of noninvasive methods to detect early onset of diseases such as aneurysms and stenosis of major blood vessels. We introduce a mathematical model which describes the interaction of blood flow with the aortic wall; the model is based on the immersed boundary method. A two-dimensional vessel model is constructed and the velocity profiles at the inlet and outlet are prescribed based on the information from Magnetic Resonance Imaging data measured for a healthy subject. The mathematical model is validated by comparing with well-known solutions of the viscous incompressible Navier-Stokes equations in arteries, i.e., Womersley flow. The hysteresis behavior in the pressure-diameter relation is observed when the viscoelastic material property of the arterial wall is taken into consideration. Five different shapes of the aortic wall are considered for comparisons of flow patterns inside the aorta: one for a normal aorta, two for dilated aorta, and two for narrowing aorta.

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