MODELING OF BOUNDARY CONDTIONS FOR HEMODYNAMIC STUDY OF CEREBRAL ANEURYSM

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An image-based simulation system is becoming an emerging diagnostic tool for the treatment of cardiovascular disease. In the system, usually a three-dimensional pulsatile flow simulation is conducted for an anatomic vascular model, which is obtained from medical imaging data such as CT or MRI using clinically measured blood flow data. Thus it can provide detailed flow features to evaluate hemodynamic factors (wall shear stress, stagnation of flow) for an individual patient. The authors have been developing an image-based simulation system to predict creation, growth and rupture of cerebral aneurysm [1], which is a main cause of subarachnoid hemorrhage.

Due to computational requirements, the simulation is performed for a limited segment, for example, a diseased area. In this case, it is important to model boundary conditions taking account of the fact that the analysis region is a part of cerebrovascular system. Thus, the paper presents the boundary condition models for both inflow and outflow, particularly the middle cerebral artery (MCA) so as to consider the entire geometry of ceberbrovascular network.

When flow data measured by the ultra sound Doppler technique are prescribed on the inflow boundary, the only axial velocity component can be determined. But because of curvature of the internal carotid artery (ICA), strong secondary flow is created. Since a magnitude of secondary flow is 10 to 20 % of the axial velocity component, it is necessary to model other velocity components. Thus the inflow boundary condition is modeled using numerical study for the modeled ICA in which the flow structure is derived varying the Reynolds number and curvature. For modeling outflow boundary conditions, the effects of brunching arteries need to be included as resistance to the upstream region. Thus in the paper, the outflow boundary conditions are prescribed as pressure boundary conditions based on lumped parameters [2], which are determined from geometry of cerebrovascular geometry. The present boundary condition models are applied to MCA and MCA with an aneurysm. The results are compared to show applicability of the boundary condition models.

References

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