BIOSIMULATION AND VISUALIZATION

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Hemodynamics plays an important role in cardiovascular disorders. The authors have been working on numerical and experimental studies of intracranial blood flow for creation and rupture of intracranial aneurysms. In this paper, the simulation is conducted by a finite element method (FEM) while the experiment is conducted by particle imaging velocimetry (PIV). In order to examine how curvature of the carotid siphon affects hemodynamics such as flow patterns and wall shear stresses, the curved tube model is used for both numerical and experimental studies. Comparison between the numerical and experimental results shows similar secondary flow behavior.

INTRODUCTION

A subarachnoid hemorrhage is mainly caused by rapture of an intracranial aneurysm. However, according to the paper published in the New England Journal of Medicine in 1998, the rate of rupture of aneurysms is relatively low[1]. Thus, it is necessary to predict the risk factors of rupture of aneurysms in order to avoid unnecessary surgery. According to medical statistics, the intracranial aneurysm tends to be created in preferential areas, among preferential age groups[2]. This evidence can lead to the hypothesis that the rupture of aneurysms is related to the hemodynamic factors associated with the geometry of arteries.

METHODOLOGY

The junction of the internal carotid and the posterior communicating arteries is one of preferential locations where the intracranial aneurysm occurs. The distinct characteristic of vascular geometry of the junction is bifurcation after large curvature of the internal carotid artery. Thus, in order to investigate curvature effect, the internal carotid artery is modeled as the curved tube, as shown in Fig.1. The experiment is conducted with a curved tube whose size is 2.5 times larger than the one used in the simulation. The test section, shown in Fig.2, is formed in a transparent acrylic resin. The experiment is conducted using particle imaging velocimetry (PIV)[4] as shown in Fig. 3. To avoid refraction between the model and the working fluid, liquid silicon is used for the three-dimensional model while a saturated aqueous solution of sodium iodide with the refraction index (1.495) is used for the curved tube

The numerical simulation is conducted using FEM[3]. The experiment was conducted using particle PIV[4] as shown in Fig. 3. For the simulation, the physical properties of blood were set to be as water density, $\rho = 1.00$ g/cm^3, and the kinematic viscosity ν (=μ/ρ)= 0.02poise.These values are close to the real physical values of blood. For the experiment, both simulation and experiment were performed at the Reynolds number 150. Figure 4 compares the experimental and numerical results.

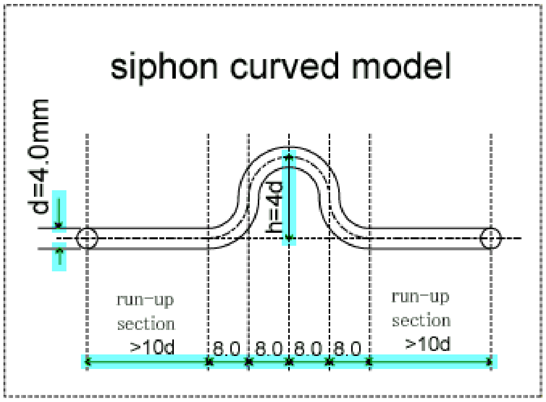

Fig. 1 Curved Tube Model

Fig. 2 Test section for the experiment

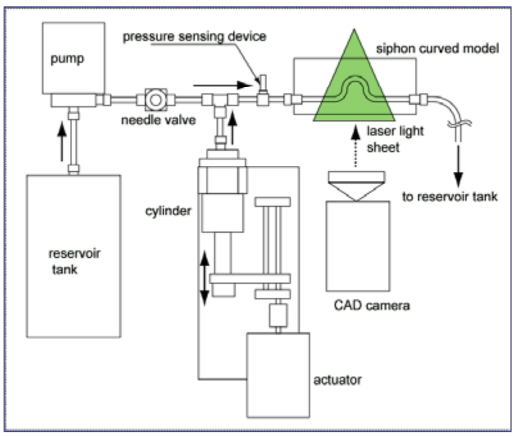

Fig. 3 Experimental set up

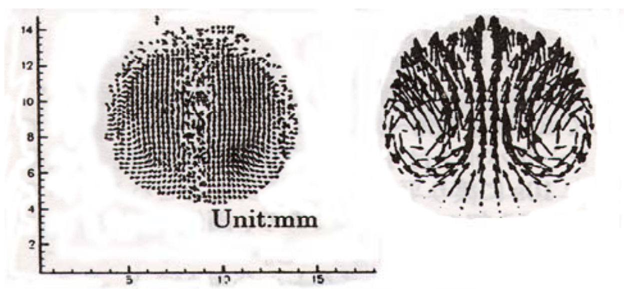

Fig.4 Comparison of experimental and numerical results

As shown in Fig, 4, a similar secondary flow behavior is observed for both the experimental and numerical studies.

CONCLUSIONS

Numerical and experimental studies on flow in a curved tube model were conducted in order to examine the curvature effect of the internal carotid artery on hemodynamics. The experiments and simulations were performed at the same Reynolds number. A similar secondary flow behavior was observed and both results showed good qualitative agreement.

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