IMAGE-BASED, COMPUTATIONAL MODELING OF BLOOD FLOW IN A CEREBRAL ARTERY WITH MULTIPLE ANEURYSMS

K. Yokoi[1] , H. Liu[1], K. Fukasaku[2] and R. Himeno[1]

[1]Computer and Information Division
The Institute of Physical and Chemical Research (RIKEN)
Wako-shi, Saitama, JAPAN

[2]Department of Neurosurgery, Motojima General Hospital
Oota-shi, Gunma, JAPAN

INTRODUCTION

Rupture of an intracranial aneurysm causing ubarachnoid haemorrhage (SAH) occurs with a frequency of between six and eight per 100 000 in most western populations. It has been reported that, in younger (younger than 60 years old) population, there are approximately 0-3.1% male and 0-3.4% female suffering from aneurysm(s); and in older (older than 60 years) ages, this tendency increases significantly up to 4.3-4.9 % for male and 7.4-12.0% for female with an averaged rupture rate of about 0.05-3% annually. Furthermore, 30-40% people die of initial rupture whereas 33 % of patients suffer re-rupture, and 10 % of the patients pass away during their medical treatment. Thus, prediction of the risk factor of when and how the aneurysm would rupture is of great importance in the medical treatment course and we hope that image-based blood flow visualization on a basis of computational fluid dynamic modeling may provide useful information for neurosurgeons in addition of qualified medical images and their experiences.

The objective of this work is to establish a new computational fluid dynamic modeling method for blood flow simulation in the cerebral artery with multiple aneurysms. The complicated multi-aneurysm cerebral artery model is constructed based on the X-ray CT images of solid model (Fig. 1) made of a patient subject who died of the rupture of the cerebral aneurysm. A new computational fluid dynamic method has been developed to use the threshold information of the raw images in a straightforward way so that the time-consuming mesh generation can be skipped. Also, the interaction between blood flow and blood vessel can be solved in a unified scheme. The model is based on the level set method[1-3], the CIP-CUP method[4] and the ghost fluid method[5], and can capture the boundary layer and complex shape in a Cartesian fixed grid.

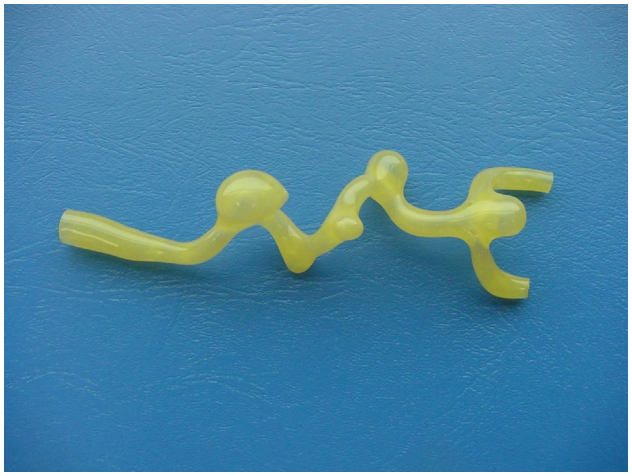

Fig. 1. A cerebral artery model with multiple aneurysms

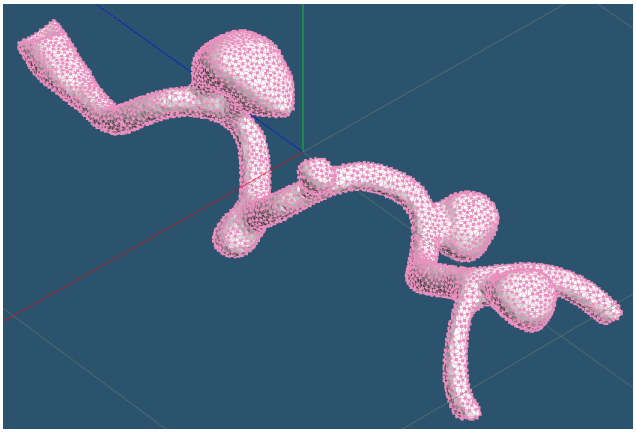

Fig. 2. The constructed computational model of the multi-aneurysm cerebral artery

REFERENCES

1. S. Osher and J.A.Sethian, J. Comput. Phys. 79, 12 (1988).
2. M. Sussman, P. Smereka and S. Osher, J. Comput. Phys. 114, 146 (1994).
3. K. Yokoi, Phys. Rev. E, 65, 055701(R) (2002).
4. F. Xiao, J. Comput. Phys. 155, 348 (1999).
5. R. Fedkiw et al., J. Comput. Phys. 152, 457 (1999).
6. Liu H, Shyy W, Kitawaki T, and Himeno R, 2002, "Multi-scale computational hemodynamics in cardiovascular system", *Proc. The 4th World Congress of Biomechanics*.