WCSMO-10
title: Application of optimization for design of intracranial stent with Blood flow reduction as Objective function

Cerebral aneurysm is one of the vascular disorders with distending the vessel wall. To produce an optimal design of stents for cerebral aneurysm is attracted for reducing the flow in the aneurysm efficiently and we have introduced a methodology combining simulated annealing (SA) optimization to lattice Boltzmann (LB) simulations. The previous results using this method in 2-D optimization have confirmed a new concept of design for stent and have revealed that covering aneurysm neck using new stent obtained by this method would reduce the flow more effectively, even under the same porosity. This report demonstrates the design optimization of stent using a 3-D ideal side wall aneurysm and then compares optimal stent characteristics obtained by two types of objective function.

Aneurysm model assumes an arterial diameter of 3.50 mm with a curvature of $1.7\times10^{2}\ m^{-1}$ and an aneurismal diameter of 4.8 mm. Stent model was constructed on the neck plane as a combination of 36 thin struts, assuming porosity of 80%. Steady velocity boundary was imposed on the inlet and constant pressure boundary on the outlet. Objective for the optimization was set as an average velocity or maximum velocity in an aneurysm sac. All stent models have an uniform distribution of struts as an initial state. Then, the SA process was performed with applying modifications to the stent geometry. Stent modification was obtained by random exchange of strut position and direction.

The results show the change of flow direction in an aneurysm as well as the change of inflow/outflow position due to the deployment of initial stent. The initial stent stalls the momentum of the inflow, and then especially the rotation direction of flow inside an aneurysm changes into the opposite direction with comparison to w/o stent case. This change of inflow/outflow position may be attributed to secondary flow in a parent artery. Ratio of horizontal/vertical momentum to the neck plane may strongly affect a momentum loss due to a strut. The optimum stent for average velocity reduction has denser struts on the inflow zone observed in the initial stent case. Thus, strut placement in the inflow area may assume a critical role for average velocity reduction in an aneurysm. On the other hand, the optimal stent for maximum velocity reduction has lower density of struts than that of average velocity case. Denser strut distribution on the inflow zone sometimes causes high speed flow through the gap of struts. Therefore the searching for threshold of porosity may become one of the guideline for development of stent design.

The relationship between the inflow zone and strut position can be an important concept of strut design that especially focuses on the inflow. In addition, the variety of strut pattern for each aneurysm may indicate the requirement of tailor-made implant for the treatment of aneurysms.