Computational Methods for Aneurysm Rupture Prediction

Specific problem

According to a recent survey conducted among 400 adult volunteers who underwent clinical and radiological evaluations, Dr. Nakagawa reported the incidence of un-ruptured Intracranial Aneurysms (IA's) to be as high as 7%. A brain aneurysm is called as cerebral or Intracranial Aneurysms. It is an abnormal bulging outward of one of the arteries in the brain. Brain aneurysms are often discovered when they rupture, causing bleeding into the brain or the space closely surrounding the brain called the subarachnoid space causing a Subarachnoid Hemorrhage (SAH). SAH from a ruptured cerebral aneurysm can lead to hemorrhagic stroke, brain damage and death. Hence, it is required to determine whether the particular aneurysm has a high risk of rupture so that it can be treated before bleeding occurs. There are certain cases wherein neurosurgeons fail to judge the risk of rupture even with their profound experience and decide not to meddle with it. Such was a problem that was shared with us by a group of doctors wherein we are supposed to predict the rupture status of IA's.

Solution

CFD have proved to be useful for understanding IA rupture by evaluating the hemodynamic parameters in patient specific geometries. What makes us unique is our ability to model the patient specific geometries with their proper material characteristics that would mimic human body conditions, while the conventional studies fail in this aspect.

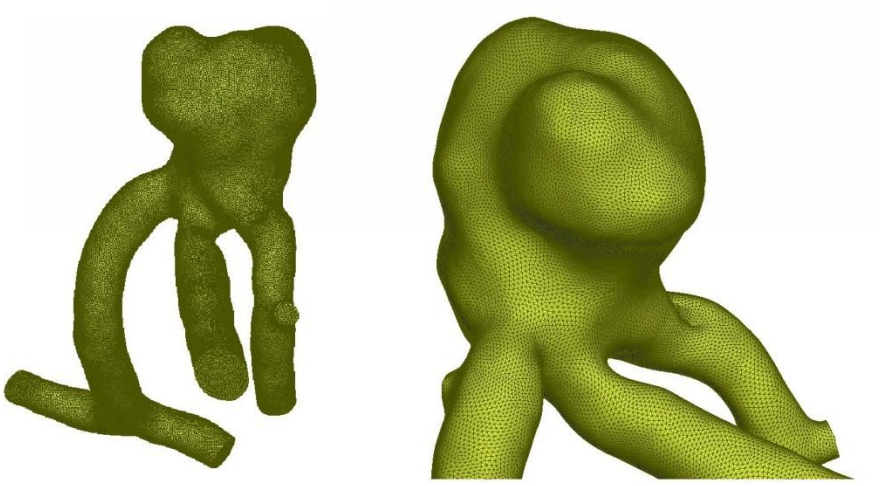

Fig. 1 Middle Cerebral artery Aneurysm (MCA)

Through computational analysis we analyzed the hemodynamic stresses like Wall Shear Stress (WSS) and other derived parameters such as TAWSS (Time Averaged WSS) and Oscillatory Shear Index (OSI) that acts directly on the vascular endothelium as a biological stimulator and contributes aneurysm growth and rupture. The feasibility of measurement of these hemodynamic stresses in vivo even for small and tortuous intracranial arteries through CFD, this has helped a lot in IA rupture prediction.

Bottom-line Results

We found that high and low WSS were mixed in the small aneurysm area high WSS is appeared at the body or neck of the aneurysm. However at the tip, the stasis of the blood with recirculation zones was observed, which resulted in low WSS in that region. We concluded that this low WSS at the tip or bleb made the aneurysm fragile and resulted in rupturing.