Computational Fluid Dynamics Analysis of Intracranial Sidewall Aneurysms

Student: Erik Lamoureux
Project Sponsor: Dr. Dana Grecov
Project Period: September 2018 – April 2019

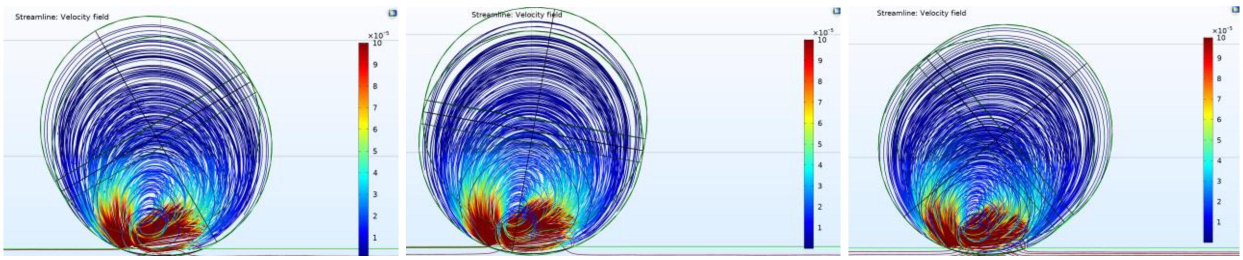

Figure 1: Posterior cerebral artery velocity streamline (m/s) plot with filtering cutoff above 0.1 mm/s for inlet angles of 60° (left), 100° (centre), and 140° (right).

Intracranial sidewall aneurysms are characterized by the weakening and dilation of an intracranial artery wall (whereas bifurcated aneurysms occur at vessel junctions). Intracranial aneurysms are at risk of rupture and may lead to severe disability or death.

Computational models of aneurysms are modelled based on anatomical parameters for seven locations in the brain. Computational fluid dynamic analyses are conducted in COMSOL Multiphysics to simulate the haemodynamic (non-Newtonian) flow. As the flow through the artery hits the aneurysm opening, flow impinges at the distal junction between the aneurysm and the vessel wall. The maximum velocity and wall shear stress in the aneurysm occurs here. The entrance flow creates an anticlockwise vorticity that is symmetric about the vertical mid-plane (see flow streamlines in Figure 1). Cases with large aneurysm to vessel diameter ratios experience marked fluctuations when the inlet angle into the aneurysm is varied. This may indicate that large aneruysm size ratios suggests instability of the aneurysm and that its flow is more sensitive to geometric changes.

Future computational and experimental work needs to be done to further validate these results. This work is of use to medical device companies designing stent-like devices to reduce the risk of aneurysmal rupture.