The Influence of Dome Size, Parent Vessel Angle, and Coil Packing Density on Coil Embolization Treatment in Cerebral Aneurysms

A cerebral aneurysm is a bulging of a blood vessel in the brain. Aneurysmal rupture affects 25,000 people each year and is associated with a 45% mortality rate. Therefore, it is critically important to treat cerebral aneurysms effectively before they rupture. Endovascular coiling is the most effective treatment for cerebral aneurysms. During coiling process, series of metallic coils are deployed into the aneurysmal sack with the intent of reaching a sufficient packing density (PD). Coils packing can facilitate thrombus formation and help seal off the aneurysm from circulation over time. While coiling is effective, high rates of treatment failure have been associated with basilar tip aneurysms (BTAs). Treatment failure may be related to geometrical features of the aneurysm. The purpose of this study was to investigate the influence of dome size, parent vessel (PV) angle, and PD on post-treatment aneurysmal hemodynamics using both computational fluid dynamics (CFD) and particle image velocimetry (PIV).

Flows in four idealized BTA models with a combination of dome sizes and two different PV contact angles were simulated using CFD and then validated against PIV data. Percent reductions in post-treatment aneurysmal velocity and cross-neck (CN) flow as well as percent coverage of low wall shear stress (WSS) area were analyzed. In all models, aneurysmal velocity and CN flow decreased after coiling, while low WSS area increased. However, with increasing PD, decreases in aneurysmal velocity and CN flow, as well as increases in low WSS area, were greatest in aneurysms with smaller dome sizes. Overall, coiling affected greater relative hemodynamic change in aneurysms with smaller domes, especially with increasing PD. The results of this study show that aneurysmal geometric features can affect the influence of coil embolization on post-treatment hemodynamics, and support that different treatment timing and goals may be appropriate for different aneurysmal geometries.