EFFECTS OF ASPECT RATIO ON THE HEMODYNAMICS IN ELASTASE INDUCED RABBIT ANEURYSMS

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ABSTRACT

Background and Purpose
An intracranial aneurysm (ICA) is a pathological condition of cerebral arteries characterized by local enlargements of the arterial wall, typically into a saccular shape. Rupture of the aneurysm sac results in devastating cerebral hemorrhage. Hemodynamic factors are believed to play an important role in ICA initiation, development and rupture [1,2]. Clinical studies suggest aneurysm aspect ratio (AR) (sac height/neck width) is an important indicator of likelihood of rupture [3]. The significance of the AR on rupture risk is believed to be due to its impact on the hemodynamics within the aneurysm sac, which are in turn believed to influence the structure of the aneurysm sac through the remodeling process. However, this coupling between hemodynamics and pathophysiology is complex and remains poorly understood. Animal models provide a mechanism for fundamental studies of this issue. In this work, we evaluate the influence of aspect ratio (AR) on the aneurysm hemodynamics using a previously developed elastase-induced saccular aneurysm model in rabbits [4].

Methods
Saccular aneurysms with ARs ranging from 0.56 to 3.98 were created in 51 New Zealand white rabbits at the origin of the right common carotid artery (RCCA). Of these 51 aneurysms, 25 were of low AR (AR<1.8) and 26 were high AR (AR>1.8). Computational models of the rabbit vasculature were reconstructed using 3D rotational angiography (3DRA) 12 weeks after creation. A full 3D, pulsatile CFD analysis was performed for the models with rabbit specific inflow velocity profiles obtained using duplex Doppler ultrasound data. Detailed methods are given in [5]. Wall shear stress (WSS), oscillatory shear index (OSI), and flow structures were calculated and compared between low and high AR cases.

Results
The time averaged wall shear stress (WSS) in the aneurysm sac was found to have lower magnitude and more uniform distribution in high AR aneurysms than in low AR aneurysms. Only a single, stable vortex was seen in all low AR aneurysms (n=25), whereas a secondary, transient recirculation zone in the aneurysm dome was also found for all high AR sacs (n=26). Elevated OSI was found at both the aneurysm neck and dome region for all high AR cases, whereas it was only elevated at the neck region in all low AR aneurysms. Similar flow structures and distinct cutoff AR were seen in parametric CFD studies of the influence of AR on flow in human sidewalled aneurysms [6].

Conclusions
Intrasaccular hemodynamics differ between high and low AR elastase induced aneurysms in rabbits. These differences mimic those seen in human aneurysms. The elastase induced rabbit aneurysm model provides an important tool for studying the role of AR on the pathophysiology of human aneurysms.

References

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