Analysis of Intraluminal Thrombus Influence on Abdominal Aortic Aneurysm Using Fluid Solid Growth Model

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ABSTRACT

The majority of abdominal aortic aneurysms (AAAs) harbor intraluminal thrombi (ILTs). These thrombi have a biochemomechanically active role in aneurysm evolution [1]. Therefore, it is important to consider their influence when modeling aneurysm growth. A computational model of multi-layered ILT presented in Virag et al. [2] showed diverse effects that ILT has on the AAA enlargement. However, in the study an idealized cylindrical geometry was used, and it was assumed that a new thrombus layer was deposited in every time step in which aneurysm enlarged. Yet, current thinking is that ILT is not accumulated continuously and that its deposition depends on time averaged wall shear stress (TWASS), e.g. see [3].

In this research we are using a fluid solid growth (FSG) model to analyze ILT influence on AAA enlargement. Time and location of ILT deposition is determined using hemodynamics analysis, while finite elements enable us to model aortic wall and ILT deformation in a 3D environment. Aortic wall was modeled using model from Karšaj et al. [4], while ILT was described as in Virag et al. [2]. Gaussian spatio-temporal elastin degradation in axial and circumferential direction was used to simulate development and expansion of axially symmetric and asymmetric aneurysms. Growth and remodeling (G&R) analysis of evolving AAA and corresponding hemodynamic analysis are run in an iterative time loop. After a certain change in aortic geometry (i.e., sufficient expansion) a hemodynamic analysis is performed. Thrombus accumulation is predicted when TAWSS on luminal surface is less than 0.4 Pa [5]. After inclusion of the new ILT elements G&R analysis continues until next CFD simulation is needed (e.g., due to sufficient growth of AAA). This FSG model will enable us to test hypothesis that non-continuous thrombus deposition may be one of the causes of staccato growth clinically observed in [6].

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