Numerical modeling of effects of thrombus with variable thickness on fusiform abdominal aortic aneurysm growth

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The majority of abdominal aortic aneurysms (AAAs) harbor intraluminal thrombi (ILT), which influence the aortic wall biochemomechanically and have an active role in growth and remodeling (G&R) of AAAs. Therefore, it is important to model their influence in aneurysm growth analysis [1]. The existing model of thrombus-laden AAA [2] assumed idealized cylindrical geometry of an aneurysm, constant luminal radius, and uniform thrombus thickness. Although the model provides valuable insight into the importance of complex thrombus effects on AAA evolution, an extended 3D model is needed for capturing more realistic AAA behavior and verifying hypotheses derived from simplified 1D model.

In this research, we model the growth of fusiform abdominal aortic aneurysm using a fluid-solid-growth (FSG) model developed in the previous work [3]. Briefly, the FSG model couples finite element G&R analysis of the evolving AAA with hemodynamics (CFD) analysis. Based on a time-averaged wall shear stress from hemodynamics analysis, the new ILT layers are added on luminal surface of AAA model. G&R analysis of an aneurysm and corresponding hemodynamic analysis are run in an iterative time loop, where former has longer time scale (i.e. months), while latter has shorter time scale (i.e. seconds). Using the FSG model, we plan to explore more complex expansion patterns (observed in [4]) that might be caused by axially variable thickness of ILT (i.e., where one portion of the ILT remains thinner than the other), non-continuous deposition of thrombus, and multiple regions where the wall is adjacent to proteolytically active thin thrombus throughout AAA development.

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References