COHERENT STRUCTURE AND BLOOD FLOW DYNAMICS IN THE NORMAL AND ANEURYSMATIC AORTA

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ABSTRACT

Focal enlargments of the abdominal aorta, known as Abdominal Aortic Aneurysms (AAAs), are thought to be the end results of irreversible pathological remodeling of the aortic connective tissue. The natural history of this particular vascular disease is frequently characterized by the development of an Intra-Luminal Thrombus (ILT) with multiple biochemical and biomechanical implications. In order to examine the effect of blood flow in ILT fluid-driven growth, we investigate here the fluid dynamics inside normal and aneurysmatic aortas using the λ_2 vortex eduction method [1] and, specifically, a possible correlation between vortexes and ILT-formation.

Starting from patient-specific luminal geometries segmented from Computer Tomography scans, full 3D unsteady CFD simulations were performed. The non-Newtonian behavior of blood was modeled by the Carreau-Yasuda model and physiologically appropriate boundary conditions were prescribed. Coherent vortical structures were extracted using the λ_2 method [1] and tracked during the whole cardiac cycle.

The low Stokes number implies that platelets closely follows the flow [2], and, hence, vortex motion can be used for an assessment of platelet motion. In particular, platelets may be 'trapped' by a vortex, which in turn forces their further motion until they are released after vortex breakup. Our results showed also that the downward motion of a vortex in the AAA is in the range of a few centimeters per cardiac cycle, such that the release of activated platelets (from the vortex) may still be within the lower part of the diseased artery, i.e. where the thickest ILT layer is frequently observed. This conclusion further reinforces a previously hypothized mechanism regarding the formation of ILTs in AAAs [3].

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