Multiscale Modeling of Tissue Mechanics and a Novel Wall Shear Stress Risk Assessment in FSI Models of Large Vessels

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ABSTRACT

In the present study, a multiscale anisotropic non-linear elastic tissue response is coupled with a multiscale fluid-structure interaction (FSI) description of large arterial vessels. Tissue constitutive description accounts for histological features of the arterial wall, mainly affected by the collagen hierarchical organization [1]. Tissue mechanics is modelled by integrating histological and chemico-physical data within a multiscale structurally-motivated approach, coupling both geometric and material non-linearities [2]. Pulsatile blood flow is described via an ALE formulation and by involving a 0-dimensional model for treating boundary conditions on a realistic three-dimensional vessel segment.

The proposed approach, implemented in a non-linear finite-element scheme, accounts for pre-stresses and allows for patient-specific FSI analyses, enabling to investigate thrombus deposition risks associated to the occurrence of altered wall shear stress (WSS). To this aim, WSS assessment is performed through novel risk indicators based on the recent Three-Band Decomposition method [3, 4]. In addition, the proposed computational framework allows to identify accurate stress and strain patterns at the tissue level and as depending on tissue microstructure, opening to clarify the etiology of some cardiovascular diseases and physio-pathological remodeling mechanisms.

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