A MESOSCOPIC MULTIPHASE MODEL OF SMOOTH MUSCLE CELL STRUCTURAL DYNAMICS

Antonis Marousis[1], Konstantina Psaraki[1], Yannis Dimakopoulos[1,*]

[1]Laboratory of Fluid Mechanics and Rheology, Department of Chemical Engineering, University of Patras, Patras 26500, Greece

* dimako@chemeng.upatras.gr

ABSTRACT

Smooth muscle cells (SMCs), one of the primary components of the arterial walls, change their dimensions, structure and morphology in response to mechanical stimuli [1]. Through contraction and relaxation, vascular SMCs regulate the local blood flow and control the vascular tone. Thus, it is essential to know the mechanical properties of SMC in the dilated and extracted state, to investigate in depth the behaviour of the vascular walls. Vascular smooth muscle cells are splined-shaped and their intracellular space encompasses the nucleus, the cytoskeletal as well as smaller organelles, and filaments, which run mostly parallel to their major axis and determine the mechanical properties of the cell [2]. In the present study, we examine the dynamics of the cell under compression and extension and identify the mechanical properties of the cytoplasm. To this end, we have developed a three-dimensional multiphase model that incorporates the structural dynamics and the interactions between the main subcomponents of the SMC; nucleus, plasma membrane and cytoplasm. More specific, the nucleus is treated as a hyperelastic solid, whereas the plasma membrane that surrounds the cell is represented as a thin, almost rigid, layer. Based on the structure of the cytoskeleton, the cytoplasm is modelled as a fibrous poroelastic medium. The cytoplasm parameters, including the elastic and shear moduli in the directions along and across the filaments, are estimated by fitting the results of the simulation with previous experimental and numerical studies.

KEYWORDS: SMC, Multiphase Modelling. FEM

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