**MATHEMATICAL MODELING OF ATHEROMA PLAQUE FORMATION AND DEVELOPMENT**

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**Introduction**

In this work, a mathematical model to reproduce the atheroma plaque growth is presented. Simplifying, the atherosclerosis process starts with the accumulation of LDL in the intima, where part of them are oxidized and become pathological. In order to remove the oxidized particles, circulating immune cells (monocytes) are recruited. Once in the intima, the monocytes differentiate and become macrophages that phagocyte the oxidized LDL. Fatty macrophages then transform by apoptosis into foam cells. Furthermore, small proteins called cytokines are secreted by macrophages due to the presence of oxidized LDL, and allow cells of the immune system to communicate with one another via cytokine receptors expressed at the cell surface. Then, the cytokines signal activates the contractile SMCs which differentiate into synthetic SMCs and migrate. Finally, the migrated SMCs segregate collagen which play a role in determining plaque stability. Foam cells, migrated SMCs and secreted collagen are responsible for the growth of a subendothelial plaque which eventually emerges in the artery lumen.

**Methods**

This model employs the Navier-Stokes equations and Darcy's law for fluid dynamics, convection – diffusion - reaction equations for modelling the mass balance in the lumen and intima, and the Kedem-Katchalsky equations for the interfacial coupling at membranes, i.e., endothelium. The volume flux and the solute flux across the interface between the fluid and the porous domains are governed by a three pore model. The main species and substances which play a role in the early atherosclerosis development have been considered in the presented model, i.e. LDL, oxidized LDL, monocytes, macrophages, foam cells, smooth muscle cells, cytokines and collagen. Furthermore, experimental data taken from the literature have been used in order to determine physiologically model parameters. The developed model has been implemented on a representative axisymmetric geometric coronary artery model.

**Results**

Fig (1) shows the volumetric growth for the case of high blood cholesterol level during ten years. The color legend indicates the displacements. The stenosis grade after 10 years is approximately 85%

![Fig (1). Total volumetric growth after 10 years for for high blood cholesterol level](image)

**Discussion**

A mathematical and computational model of atheromatous plaque emergence which allows the lesion to grow in particular area in relation with hemodynamics of the blood flow has been presented. The atheroma plaque growth is a complex process, involving a high number of biological processes and species. However, despite that the developed model is relatively simple, it captures some of the main features of atherosclerosis lesion formation. The presented model is in good agreement with the clinical hypothesis that correlates atherosclerosis occurrence with low WSS. Moreover, the obtained results are reasonable within the biological process of atheroma plaque growth.

**References**