A COMPUTATIONAL MODEL OF ENDOTHELIAL CELL REORIENTATION DUE TO ARTERIAL FLOW

Pablo Sáez[1], Mauro Malve[1,2], Estefanía Peña[1,2], Miguel Ángel Martínez[1,2]

[1] *Department of Mechanics, University of Zaragoza, Zaragoza, Spain*

[2] *CIBER-BBN, Centro de Investigación Biomédica en Red en Bioingeniería, Biomateriales y Nanomedicina, Spain*

Introduction

Endothelial cells (EC) are key elements in mechanotransduction and react to the blood flow [Li, 2005]. They reorganize its internal structure based on the flow features. EC synthesize different kind of biological substances which make the blood vessel to adapt to external stimuli. In this work we present a mechanical model to study the morphological remodelling of EC.

Methods

Our mechanical model is based on a micro-sphere-based approach for the mechanical description of the EC, within a hyperelactic description [Alastrue 2010]. The SEF function is given as

$$\Psi_{cell} \approx \sum_{i=1}^{m} \rho_i w_i \psi(\bar{\lambda}_i) \qquad (1)$$

Where the morphology of the cell can be gathered by a Bingham distribution ρ.

The adaptation of the EC cell shape due to mechanical stimuli is computed by means of the reorientation of the orientation vector of by an exponential mapping as

$$\mathbf{r}_i^{n+1} = \exp(\hat{\mathbf{n}}_i^{\omega} \Delta t) \cdot \mathbf{r}_i^{n} \qquad (2)$$

A common cell-shape factor (CSF) used to describe the morphological features of EC is the short/long axis ratio. It is well known that both wall shear stress (WSS) and oscillatory shear index (OSI) [Dai 2004] are the most important factors for EC remodelling.

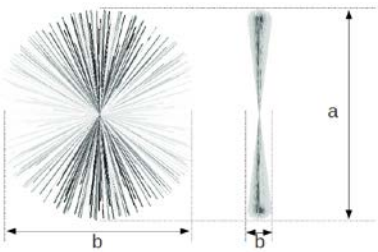

Fig (1). *EC shape index is given by the b/a ratio.*

Results

WSS values in a patient specific human carotid artery are shown in Fig. (2).

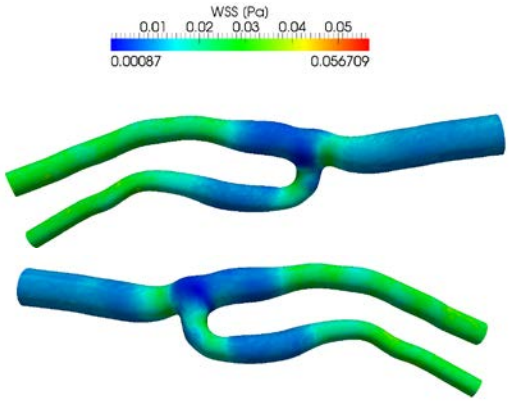

Fig (2). WSS field in the carotid artery.

Based on WSS and OSI results in the carotid artery we can compute the CSF in the different points of the vessel. In the Table (1) we show the variation of CSF due to shear stress.

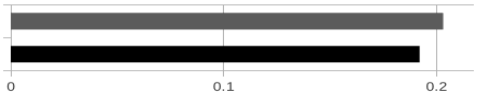

Table (1). Variation of CSF by [Malek 1996] (black) and computed (grey).

Discussion

Understanding the adaptation of EC to the blood flow stimuli is a key issue on the framework of atheroma plaque formation, SMC growth and proliferation.

In this work we investigate a mechanical model for EC remodelling based on mechanical stimuli. We see that it leads to a random distribution of the EC in zones of the carotid artery with turbulent flow while they get a more long shape in zones with laminar flow, corresponding to an experimentally observed behaviour. Our approach can be a starting point for further research the formation of atheroma plaque and SMC growth.

References

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