PARAMETRIC STUDY OF AN ATHEROSCLEROTIC ARTERY USING FLUID-STRUCTURE INTERACTION APPROACH

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Introduction

Cardiovascular diseases are nowadays primary cause of mortality in the modern civilization. Among these it is included the coronary artery disease (WHOROE, 2002). In this class, atherosclerotic diseases caused by formation, developing, and rupture of atheromatous plaques play the most important role. Through geometrical variations among physiological range of selected parameters, the vulnerability of the plaque is analysed under fluid-structure interaction (FSI) approach with aim to understand which parameter is more important for plaque developing and rupture.

Methods

The structural model of the atherosclerotic artery was build by means of the software Abaqus (Figure 1). Two layers compose it: media and aventitia. In addition, plaque and lipid core are also considered. Arterial wall is modelled as hyperelastic fiber-reinforced material [Holzapfel, 2000].

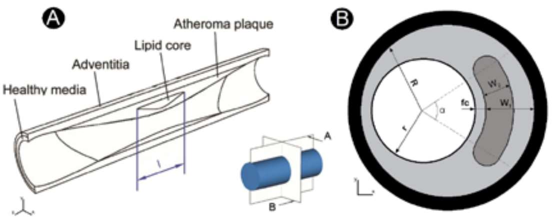

Figure 1: Geometrical model of the atherosclerotic artery.

Four parameters were considered: plaque thickness, lipid core length and width and stenosis ratio (r/R, see Fig. 1). Finally, five variations of each parameter were studied and 17 FSI models were built. Overall dimensions for the parametric study were taken from literature [Bluestein, 2008]. Blood flow was considered as laminar and non-Newtonian under unsteady conditions. Flow and pressure waveforms were applied as boundary conditions [Davies, 2006]. Numerical computations were performed with the commercial package Adina R&D.

Results

Flow recirculation after the stenosis generates a non-uniform wall shear stress (WSS) distribution that was correlated with the maximal principal stress (σ_{MAX}) and maximal strain of the arterial wall (Figure 3).

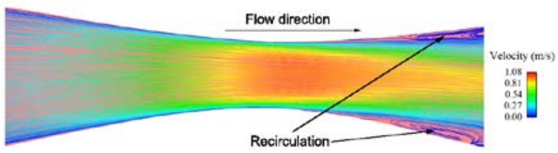

Figure 2: Flow recirculation after the stenosis.

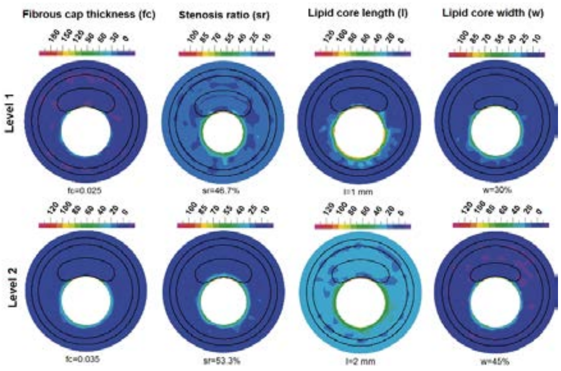

Figure 3: Maximal principal stress σ_{MAX}.

Discussion

We observed that the most important factor for plaque vulnerability on σ_{MAX} was the plaque thickness. However, also plaque width and length resulted in an important increase of σ_{MAX}. On the contrary, plaque lumen radius resulted very important for max/min WSS values that may promote plaque developing and growing.

References

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