NUMERICAL SIMULATION OF WALL DEFORMATION IN AN ANEURYSM MODEL

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ABSTRACT

This work presents the numerical assessment of the deformation of an artery wall with and without an aneurism. The simulations consider the hyper-elastic behaviour of the artery tissues, taken in consideration the properties of polydimethylsiloxane (PDMS), which are more similar to the biological tissues. The numerical simulations were performed using the commercial finite element routines ANSYS®, by considering the inner the artery fluid flow and the consequent pressure is used to simulate the wall deformation.

Keywords: aneurysm model, polydimethylsiloxane, hyper-elasticity, finite element method.

INTRODUCTION

Aneurysms are the fourth most common cause of cerebrovascular disease in adults, after the ischemic attacks, thrombotic and hypertensive cerebral hemorrhage. In Europe, the cerebrovascular diseases are the leading cause of mortality (Branco, 1992). The causes for the occurrence of aneurysms are the deterioration of the arterial wall is the hypertension. Other causes include hereditary connective tissue disease, congenital cardiovascular abnormalities or atherosclerosis. An aneurysm is an excessive dilation of the wall blood vessel that can occur in an artery or a vein. However, there are no known ways to prevent the formation of aneurysms. For that reason, an approach to the study of aneurysms behavior may be made from analysis of the blood flow in this region and deformation occurred caused by blood pressure.

One of the important features in this study relates to the mechanical properties of the arteries tissues. Some studies have shown that arterial tissues have a typical hyper-elastic behavior (Masson, 2008). These materials are characterized by exhibiting high deformation prior to reaching the tensile strength. As initial approach, it was chosen the polymer PDMS as material model of arterial tissue for the simulations. PDMS is a biomaterial well known for its biocompatibility and its low cost that make it a material used in various biomedical (Bélanger, 2001).

The numerical simulations were carried out based on the finite element method (FEM) which allows high accuracy and precision results. The FEM simulations were developed using two different approaches: fluid flow and structural analysis. For the fluid flow analysis was considered a constant flow of 300 µl/min of glycerin. Whereas the structural simulation, used the pressure obtained previously in the fluid flow analysis and the hyper-elastic properties of the PDMS materials that were determined in experimental tensile test.
RESULTS AND CONCLUSIONS

The results from the numerical simulations are shown in Fig. 1. In Fig. 1(a) we can observe the dynamic pressure simulated in the Fluent module of the Ansys®, and in Fig 1(b) the resultant displacement field in the PDMS model using the hyper-elastic constitutive model of Mooney-Rivlin. The constants of the material constitutive model were obtained by adjusting the numerical curve to the strain-tress curve previously measured during tensile test of PDMS material (Fig. 2).

![Fig. 1 - Numerical simulations of aneurysm model: (a) Dynamic pressure and (b) displacement field.](image)

The study shows that there are substantial differences on fluid flow behavior in the channel with and without the aneurysm. In the channel without aneurysm occurred a laminar flow, but with the aneurysm was observed a turbulent flow. The displacement and strain fields were greater in the presence of aneurysms.

REFERENCES

