NUMERICAL MODELLING OF INTERACTION BETWEEN CAROTID ARTERY WALLS AND BLOOD

Nebojsa Zdravkovic[a], Milos Kojic[b], Mirko Rosic[a], and Nenad Filipovic[b]

[a]Faculty of Medicine, University of Kragujevac, Kragujevac, Serbia

[b]Faculty of Mechanical Engineering, University of Kragujevac, Kragujevac, Serbia

nzdravkovic@medf.kg.ac.rs, fica@kg.ac.rs

Key words:Carotid artery, Blood flow, Solid-fluid interaction, Stress-stretch relation

INTRODUCTION. We first present an experimental determination of carotid artery properties by using strips of human carotid artery. The strips were taken in the longitudinal and in the circumferential directions assuming that the carotid artery wall has the orthotropic characteristics. The material was subjected to uniaxial tension and the stress-stretch curves were obtained for various rates of deformation. It was found that the rates do not have significant effects on the passive response of the material. Next, we employ the measured non-linear stress-stretch dependence to determine the coefficients in the analytical form of this dependence by a standard fitting procedure. We give description of the numerical procedure, considering the carotid artery as a thin-walled shell structure subjected to blood pressure. We calculated behaviour complete human carotid artery by solving coupled problem interaction between artery walls and blood pressure on its. METHODS. A total number of 30 segments of carotid artery were used. Different initial strip lengths were taken in the longitudinal and in the circumferential directions and strained continuously using various strain rates. The developed force was measured by an isotonic transducer (Elunit, Yugoslavia) and recorded using PIC digital recording system (ECM, Yugoslavia). As the initial length we considered the measured strip length just before visible change in tension was recorded on PIC digital recording system. Pulsatile flow waveform in the carotid artery during systole and diastole phases is taken from literature (Perktold and etc., 1991; 1994) RESULTS. We employ the measured nonlinear stress-stretch curves in our material model within finite elements for geometrically and materially nonlinear analysis. We give description of the numerical procedure, considering carotid artery as a shell structure subjected to pressure loading. We calculated behavior of complete human carotid artery observing unsteady blood flow through artery, namely it was performed dynamic analysis interaction between artery walls solid and blood fluid. It was performed comparing obtained numerical results velocity fields in XY symmetry plane, von Mises stress distribution, wall shear stresses, etc. with results received for case when walls are considered as elastic and with results in literature. DISCUSSION. We have presented a new methodology which employ experimentally determined real characteristics of carotid artery walls, represented through constitutive stress-stretch relation. Non-linear stress-stretch characteristics are employed as the basis for non-linear orthotropic material models in the finite element method. Large displacements and large strains are considered during interaction between artery walls and blood. The numerical simulations demonstrate the possibilities of modelling the complex mechanical behaviour of carotid artery, treated as a thin-walled structure. The proposed methodology provides a solid basis for deeper understanding of the carotid artery response during interaction between walls and blood.