8th World Congress of Biomechanics

O1974 Importance of blood elastic property in the arterial hemodynamics: a patient-specific numerical study

Sónia I.S. Pinto[1], Catarina F. Castro[1], Carlos C. António[1], Nuno Bettencourt[2], Luisa C. Sousa[1]

[1]Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), Engineering Faculty, University of Porto, Porto, Portugal. [2]Cardiovascular R&D Unit, Faculty of Medicine, University of Porto, Porto, Portugal

Abstract

Introduction

Cardiovascular diseases are one of the main causes of death, in humans, in developed countries. The clinical practice shows that specific locations in circulatory system are sensitive to atherosclerosis development. The artery images/scans provide information about the geometry and disease location; however they do not explain the hemodynamics. Numerical studies have gained importance, as an auxiliary tool, for the treatment and prevention of atherosclerosis.

As far as we know, numerical works, in the literature [1], do not consider, simultaneously, many realistic approaches: elastic and shear-thinning blood behavior, pulsatile flow, fluid-structure-interaction. The present work shows an In-House developed software which simulates, as real as possible, the hemodynamics. A constitutive equation, Phan-Thien-Tanner-PTT-Model, was implemented and validated in OpenFOAM code to take into account the blood elastic property. The goal is to conclude about the importance of considering the elastic blood behavior in hemodynamics of patient-specific arteries.

Methods

Ultrasound and computed tomography scans were provided by the medical team for the reconstruction of carotid (CCA) and left coronary (LCA) arteries through FEMAP® and MIMICS®, respectively. Then, the geometries were imported to ANSYS® to create the meshes. The meshes were then fed to the In-House OpenFOAM code for 3D numerical simulations.

Results

Velocity profiles, at systole peak, considering elastic property of blood (multimode-PTT model [2]) and not considering elastic property (Carreau Model [3]) are represented in Fig.1a for a CCA (8mm diameter) and in Fig.1b for a LCA (3.6mm diameter).

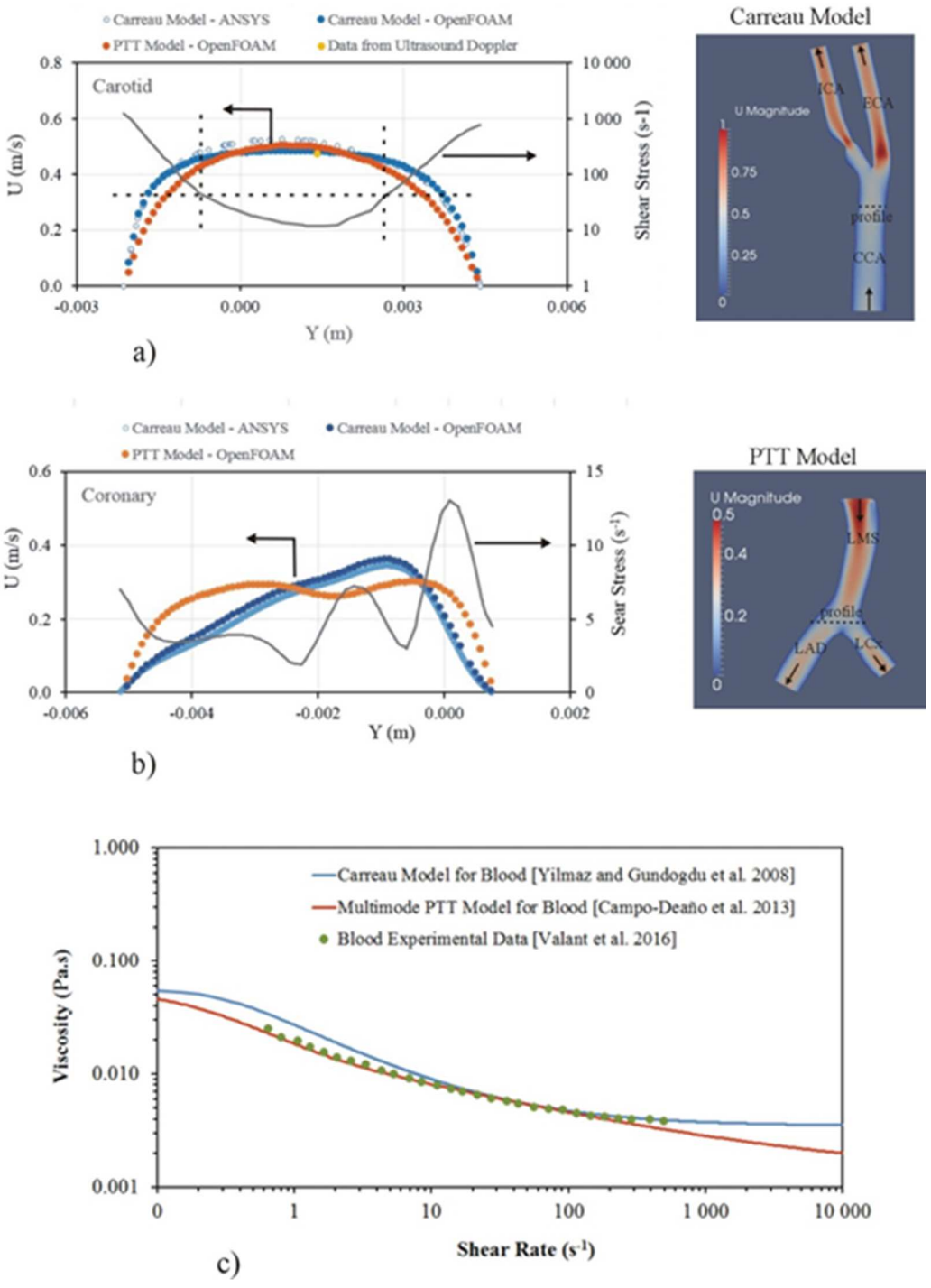

Fig.1: Velocity/Shear Rate vs. Y coordinate in a specific location of **(a)** CCA, **(b)** LCA, **(c)** Viscosity vs. Shear Rate.

Discussion

When shear stress in the CCA is between 10-70s^{-1}, velocity profiles using Carreau or PTT model are coincident. Fig.1c shows that, for this range, experimental data [4] overlaps both models. For shear stress values much higher than 70s^{-1}, Carreau model approximates experimental data, tending to a plateau.

In the LCA, shear stress presents low values, among 2-15s^{-1}. Velocity profiles considering Carreau or PTT are significantly different. Fig.1c shows that blood experimental data are according to PTT model when shear rate is lower than 10s^{-1}.

Arteries with small diameters present low shear rate and the elastic blood behavior has an important role on the blood flow pattern.

Acknowledgements

FCT, Portugal; Research Unit of LAETA-INEGI, Engineering Faculty of University of Porto; Cardiovascular R&D Unit, Medicine Faculty of University of Porto.

References

1.Chaichana, T., et al., (2013). *Physica Medica*, **29**(5), p447.
2.Campo-Deaño, L., et al., (2013). Biomicrofluidics, **7** ,p.034102 1–11.
3.Yilmaz, F., et al., (2008). *Korea-Australia Rheology Journal*, **20**(4), p.197.
4.Valant, A., et al., (2016). *Rheologica Acta*, **55**(11-12), p.921.