HEMODYNAMIC STUDIES IN 3D ARTERY MODEL FROM REAL CT SCAN

Erica Doutel, Sónia Pinto, João Campos, João Miranda
Centro de Estudos de Fenómenos de Transporte, Departamento de Engenharia Química, Faculdade de Engenharia da Universidade do Porto, Porto, Portugal

Introduction

Cardiovascular diseases are presently the leading cause of death in humans (Murray and Lopez 1997). From clinical practice, it is known that specific sites in the human circulatory system are particularly sensitive to the development of cardiovascular diseases.

Fluid dynamics studies have been used to improve the knowledge of cardiovascular diseases. Experimental *in vitro flow* studies require the construction of a model of the blood vessel under study. To measure the flow through optical techniques, the model must be transparent in the wavelength of the light used and its half thickness must be smaller than the focal distance of the objective.

In this work, a multi stage approach was developed to create 3D artery models from real CT scans in the millimetre-scale range, with or without stenosis, using melted sucrose as casting material. This method allows us to produce transparent non-contaminated PDMS channels suitable for flow visualizations and optical flow measurements. In parallel, the CT scans are processed to generate a computational mesh for hemodynamic simulations.

Methods

An overview of the fabrication process is illustrated in Figure 1. The geometry is created from CT scan data and a first mold made of an epoxy-resin is then constructed by rapid prototyping by stereolithography. Afterwards, a negative version of the mold is fabricated in non-transparent silicone. This silicone mold is used to cast a third sacrificial mold using melted sucrose. The sacrificial mold is destroyed during the final step of fabrication. After the curing step of the final PDMS artery the sucrose is removed by dissolution, in water at room temperature.

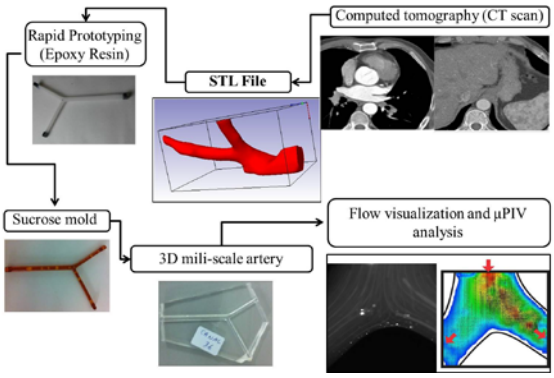

Figure 1: Schematic diagram of the study process

The final PDMS artery was used in flow visualization and µPIV studies and is suitable for optical hemodynamic studies.

Results

Experimental flow visualization and µPIV experiments were carried out in 3D model artery produced from a CT scan.

Using µPIV, it was possible to study the velocity field through the velocity profiles along the 3D mili-scale channels. The fluid used for flow visualization and µPIV was water/glycerol (39 % / 61 % w/w) mixture.

Numerical simulations were performed and they match the experimental results.

Discussion

The results show that the procedure followed makes possible hemodynamic in vitro studies which are able to mimic real patient arteries.. This procedure has the potential to develop studies of lesions in regions of extreme wall shear stresses and pressure of the patient's arteries.

References

Murray CJL, Lopez AD (1997) Mortality by cause for eight regions of the world: Global Burden of Disease Study. Lancet 349 (9061):1269-1276.doi:10.1016/s0140-6736(96)07493-4