FLOW OF BLOOD ANALOGUE FLUIDS THROUGH SIMPLIFIED INTRACRANIAL ANEURYSMS: EFFECT OF GEOMETRICAL PARAMETERS

J. Carneiro¹; L. Campo-Deaño¹; M. S. N. Oliveira²; F.T. Pinho¹

¹Centro de Estudos de Fenómenos de Transporte (CEFT), Departamento de Engenharia Química, Faculdade de Engenharia da Universidade do Porto, R. Dr. Roberto Frias, 4200-465 Porto, Portugal; ²Centro de Estudos de Fenómenos de Transporte (CEFT), Departamento de Engenharia Química, Faculdade de Engenharia da Universidade do Porto, R. Dr. Roberto Frias, 4200-465 Porto, Portugal / Mechanical & Aerospace Engineering Department, University of Strathclyde, University of Strathclyde, Glasgow G1 1XJ, United Kingdom.

ABSTRACT

From clinical practice, it is well known that specific sites in the human circulatory system are particularly sensitive to the development of cardiovascular diseases, such as cerebral aneurysms. In vivo studies are typically difficult to carry out, provide only limited information and in addition may pose ethics and safety problems. As such, in vitro studies that try to emulate physiological conditions became a common alternative.

In this work, we study the flow of blood analogue fluids in vitro through simplified geometries representative of intracranial aneurysms (ICA) with different geometries in order to better understand the flow field and the effect of different geometric parameters. Downscales versions of the aneurysms were fabricated in PDMS from SU-8 molds using soft-lithography. The microchannels include a Y-shaped bifurcation in its geometry, with the flow entering the parent vessel and exiting through two daughter vessels. The aneurysm is located at the end of the parent vessel and in between the two daughter vessels, as usually found in ICAs. We studied the effect of geometric parameters, such as the angle between the arms of the bifurcation and the width of the neck at the entrance of the aneurysm, on the fluid flow. The sizes of the aneurysm and of the vessels remain the same for all the geometries and different fluids were used, including Newtonian and non-Newtonian blood analogues to evaluate the effect of the fluid elasticity. The fluids were characterized rheologically using rotational and extensional rheometers and micro particle image velocimetry (µPIV) and streak imaging were used to characterize the flow field in the different geometries. The results confirm that the flow generated is complex and that both the rheology of the fluid as well the geometrical parameters have a strong influence of the flow characteristics.

ASSESSING THE FLOW OF LOW VISCOSITY BOGER-LIKE FLUIDS THROUGH MICROFLUIDIC ANALOGUES OF A POROUS MEDIUM

F. J. Galindo-Rosales¹; L. Campo-Deaño²; F. T. Pinho²; M. S. N. Oliveira³; M. A. Alves¹

¹Centro de Estudos de Fenómenos de Transporte (CEFT), Departamento de Engenharia Química, Faculdade de Engenharia da Universidade do Porto, R. Dr. Roberto Frias, 4200-465 Porto, Portugal; ²Centro de Estudos de Fenómenos de Transporte (CEFT), Departamento de Engenharia Mecânica, Faculdade de Engenharia da Universidade do Porto, R. Dr. Roberto Frias, 4200-465 Porto, Portugal.; ³Mechanical & Aerospace Engineering Department, University of Strathclyde, Glasgow G1 1XJ, United Kingdom.

ABSTRACT

Microchannels consisting of a sequence of abrupt contractions/expansions, disposed into symmetric and asymmetric arrangements, have been shown to reproduce experimentally the pressure gradient as function of flow rate obtained for Newtonian fluid flows in equivalent porous beds. For viscoelastic fluids, both arrangements can also predict the limiting slopes in the pressure gradients at low flow rates (or low Deborah numbers), but only the asymmetric geometry is able to predict the asymptotic slope at high Deborah numbers [1]. Apparently, this is a consequence of the combined effect of the shear thinning behavior of the viscoelastic fluids and the stronger streamline curvature in the asymmetric configuration enhancing elastic instabilities, in accordance with Pakdel-McKinley mechanism [2] (large tensile stress and strong curvature of streamlines lead to flow destabilization and an extra contribution to the pressure gradient). The analysis is done here numerically by looking in more detail at the variation of the pressure gradient along the microchannel, as well as at the characteristics of the vortices.