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MODELLING OF NON-NEWTONIAN BLOOD FLOW THROUGH STENOSED CORONARY ARTERIES

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Abstract. In this paper, a mathematical model is developed to simulate the flow of blood through stenosed coronary arteries taking into account of arterial wall deformation under pulsatile flow condition. The flow of blood through the lumen region is governed by the continuity equation and the Navier-Stokes equations, while blood flow through the poroelastic wall is described by the Brinkman equations. The deformation of coronary arteries is modelled by the equations of classical elastodynamics. The velocity field, the pressure, the wall shear stress and the deformation of the arterial wall are computed in a fully coupled manner through the use of the fluid-structure interaction condition. The influences of the severity of stenosis on blood flow and wall shear stresses are investigated.

Keywords. Mathematical modelling, blood flow, stenosis, coronary artery.

AMS (MOS) subject classification: 58F15, 58F17, 53C35

1 Introduction

Cardiovascular disease is one of the major causes of death in developed countries. Most of the cases are associated with some form of abnormal blood flow in arteries due to the existence of stenoses. When the coronary artery is affected by a stenosis, critical flow conditions occur, such as flow separation, high wall shear stress and wall compression, which are believed to be the significant factors at the onset of coronary heart diseases. In recent years, surgical treatments of cardiovascular diseases have been developed rapidly, and coronary artery bypass grafting (CABG) has been widely used for patients with severe stenosis. A large number of bypass grafts are implanted worldwide each year. However, up to 25 percents of the grafts fail within one year and up to 50 percents fail within ten years after surgery. Today, it has been recognized that one of the most important determinations in a successful bypass operation is the information of the rheological behavior of blood, the flow speed, the pressure distribution, the wall shear stress in the stenotic artery, and the wall deformation in cardiac cycles.

In order to understand the pathogenesis of coronary diseases, a number of in-vivo and vitro experiments have been conducted using animal models. Due