789. Simulation and analysis of blood flow in bypass grafts with a cuff

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Abstract. In the paper the hemodynamics in the blood vessel and in the bypass graft is simulated and analyzed. A new construction of a bypass graft with a cuff is applied. The goal of the research is evaluation of influence of the ratio between the length and the height of the bypass graft cuff upon the structure of the blood flow and pathogenesis of the blood vessel. The results of the analysis indicate that blood flow velocity at a junction of the bypass graft and the blood vessel depends on the parameters of the cuff. The best results are obtained when the said ratio is 1.25 and 1.5 due to uneven distribution of pressure in the cuff. Choosing such parameters of a bypass cuff ensures better hemodynamics and absence of haemostasia, thus reducing a risk of formation of thrombi in the bypass graft and the blood vessel.

Keywords: blood vessels, bypass end-to-end, hemodynamics, FEM.

Introduction

Atherosclerosis is a dangerous cardiovascular disease that causes a reduction of the radius of a blood vessel and impeding or blocking the blood flow. It may cause cardiac infarction, if atherosclerotic plaques are formed in coronary arteries involved in blood supply to the heart. Anastomotic intimal hyperplasia (IH) and thrombosis are the most frequent failures in bypass surgery. There are two types of cuffs: end-to-end and end-to-side [1]. Scientific references indicate that the key goal of bypass surgery is a restoration of the normal blood flow. According to the general opinion, a failure of bypass surgery is caused by the local hemodynamics [2]. Although scientific literature provides several theories of IH formation, they are not clear [3]. If an autologous vein graft is not fit, a synthetic bypass of Teflon (PTFE) or Dacron may be used. These materials are the key synthetic materials suitable for a synthetic alternate. However, development of IH in the distal part takes place both in the autologous vein and the synthetic bypass [4]. Research of animal models in vivo showed that the distal part of the junction of the blood vessel and the bypass graft, in particular, the suture line, is mostly inclinable to IH formation [6, 7]. Numerical simulation is an ideal tool for a detailed examination of various parameters that influence IH formation [8, 9]. Many factors, such as the bypass geometry, angle of the bypass and its material, affect blood flow in the bypass.

The goals of the research are: to assess the impact of the geometrical parameters of bypass grafts with a cuff upon IH formation, to establish the impact of the ratio between the length and the height of the bypass cuff upon the structure of the blood flow and pathogenesis of the blood vessel. The scientific novelty of the work includes improvement of the geometry of the bypass graft and enhancement of its functionality. The developed model of a bypass graft with a cuff enables assessing various parameters that may impact formation of thrombi.

Methods

The geometry of the model is plane. Both the bypass and the cuff are autologous, i.e. the ones of the same body. It is supposed that walls of the blood vessel are rigid, i.e. they do not deform, the velocity at the walls equals zero, so friction is avoided, and the pressure in the distal outflow of the artery is equal to zero. The artery is considered a straight tube of a regular