Stress analysis in the restored blood vessels by increasing the radius of the transcatheter angioplasty

M. Mariūnas[1], **Z. Kuzborska**[2]

[1, 2]Vilnius Gediminas Technical University, Department of Biomechanics, Vilnius, Lithuania
E-mail: [1]*mecislovas.mariunas@vgtu.lt,* [2]*zyta.kuzborska@vgtu.lt*

Abstract. This paper examines the stress in the restored blood vessels by increasing the radius of the transcatheter angioplasty. The research results show, that expanding blood vessel radius, stresses and displacements increase; it depend on blood vessel medium. More stiff vessels medium characteristics more deformed are plates and blood vessel radius increase.

Keywords: stress, displacement, pathology, transcatheter angioplasty, medium vessels.

Introduction

Many people in the world die from atherosclerosis. It damages vital blood vessels-arteries that carry blood with oxygen and food to the body's tissues. Atherosclerosis plates usually are found in the coronary, carodit arteries and aorta [1, 2, 4, 5].

Damages, caused by atherosclerosis, change blood vessels radius and wall thickness [6]. Depending on damage degree in blood vessel, expanding radius of blood vessels, stresses and displacements could reach dangerous limit. Analysis of scientific works show, that little attention is paid for research of stresses and displacements, performing blood vessels transcatheter angioplasty. Mostly stents are modeled and PTCA (PTCA – Percutaneous Transluminal Coronary Angioplasty) balloon influence to blood vessels is not performed i.e. how distribute stresses and displacements in the pathology area [3, 4].

The aim of this work – to find out stresses and displacements values expanding pathology blood vessels using transcatheter angioplasty (when there is symmetrical and asymmetric radius stenosis), estimating vessels medium and it strength characteristics.

Methods

To determine stresses and displacements in the pathological blood vessels, atherosclerosis with symmetrical and asymmetrical plate was analyzed.

Modeling was performed using ANSYS software package. Linear pathological blood vessel model was made. By evaluating the condition of deformed blood vessel and chosen finite element the 3% validation of calculation results was performed. Research was performed using two dimensional and three dimensional arterial blood vessel models.

Results

The research results show, that expanding blood vessel in damaged areas using transcatheter angioplasty, stresses in blood vessels are very high (Fig. 1 and 3), if will be no blood vessel medium, it could crack. Blood vessel displacements – Δu, when pressure $p = 2.35$ MPa, reach critical crack limit (Fig. 2 and 4) and stresses also reach blood vessel crack limit.

Performed analysis show, that expanding blood vessel using transcatheter angioplasty, its radius increase from 25 to 58% when vessel medium is plate-vessel. In medium plate-vessel-adipose tissue-muscle, blood vessel radius increase from 25 to 66%.

That way, when there is different blood vessel medium, blood vessel radius could be increased with lower pressure balloon and to decrease stresses in the blood vessel.

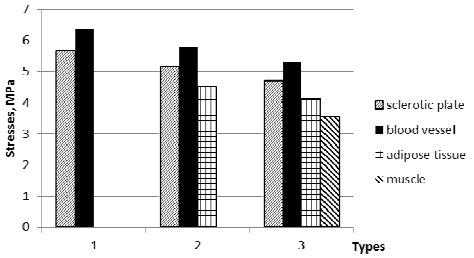

Fig. 1. Stress distribution of coronary artery

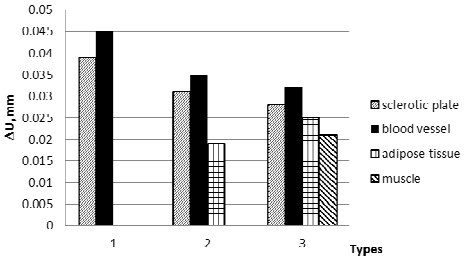

Fig. 2. Displacement distribution of coronary artery

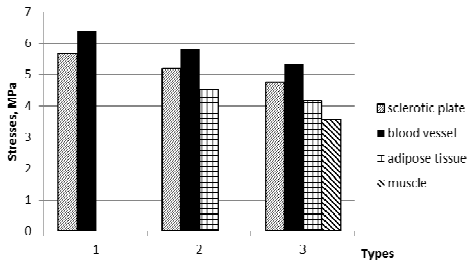

Fig. 3. Stress distribution of carotid artery

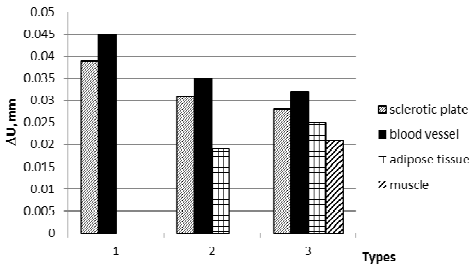

Fig. 4. Displacement distribution of carotid artery

In asymmetric case, expanding blood vessel, different mediums and different characteristics influents features occur. In the blood vessel side with sclerotic plate, stresses could reach critical limit and in opposite side lump could occur. Where blood vessel medium is minimal, stresses and displacements are big and dangerous.

Conclusions

Expanding blood vessel radius from 25 to 66%, stresses from 1,8 to 6,35 MPa and displacements from 0 to 0.045 mm increase; it depend on blood vessel medium. Medium determine if blood vessel crack or not. More stiff vessels medium characteristics more deformed are plates and blood vessel radius increase. It could be increased to 20%.

In asymmetric case, expanding blood vessel, different medium and different characteristics influents features occur.

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