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Study of main arteries stiffness in patients with coronary heart disease depending on prevalence of atherosclerosis

U.I. Nizamov *, *F.M. Bekmetova*, *S.U. Khoshimov*, *A.B. Shek*, *R.D. Kurbanov*

Republican Specialized Center of Cardiology, Tashkent, Uzbekistan

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ABSTRACT

Objective: To study the vascular wall stiffness in patients with coronary artery disease based on the prevalence of atherosclerotic lesion.

Materials and methods: The study involved 90 patients diagnosed with unstable angina class II B, the control group consisted of 27 healthy individuals. By using the SphygmoCor (AtCor Medical, Australia) apparatus, stiffness indicators, like pulse wave velocity (PWV) and augmentation index (AIx) were studied by means of the applanation tonometry method. Coronary angiography was performed on the Allura CV-20 (Philips, The Netherlands) unit, the state of the carotid arteries was studied by duplex ultrasonography, involvement of femoral arteries was evaluated based on ankle-brachial index <0.9. In case of doubt, the patients underwent ultrasound duplex scanning. In the main group, patients were divided into 3 subgroups: subgroup A covered patients with isolated coronary lesion; subgroup B covered patients with bifocal atherosclerosis (combined lesion of coronary and carotid arteries or coronary and femoral arteries); subgroup C was represented by multifocal atherosclerosis patients who had atherosclerosis lesion in three vascular basins: carotid, coronary and femoral arteries.

Results: Values of PWV (11.2 ± 1.5 m/s) and AIx ($19.8 \pm 5.0\%$) in patients with coronary heart disease were 1.5 ($p < 0.001$) and 2.4 ($p < 0.001$) times higher than in those in healthy individuals. During the analysis carried out within the groups, the PWV in all three subgroups was accelerated with maximal values in the subgroup C (13.3 ± 1.5 m/s), which with sufficient level of confidence exceeds the value of this index in the subgroups A (10.1 ± 0.6, $p < 0.01$) and B (11.0 ± 0.9, $p < 0.05$). The value of augmentation index AIx was also highest in the subgroup C ($26.8 \pm 6.4\%$), relative to the subgroups A ($13.7 \pm 2.9\%$, $p < 0.001$) and B ($18.9 \pm 4.3\%$, $p < 0.01$).

Conclusion: Patients with coronary heart disease, have demonstrated growing vascular wall stiffness, which is manifested in higher pulse wave velocity ($p < 0.001$) and augmentation index ($p < 0.001$) compared with healthy individuals. Whereas in the multifocal atherosclerosis (coronary, carotid and peripheral arteries) were higher AA ($p < 0.05$), AIx ($p < 0.001$), PWV ($p < 0.01$) and the age of patients ($p < 0.01$). That allows

* *Corresponding author.* Tel.: +998 935904747.
E-mail address: ulugbek_nizamov@mail.ru (U.I. Nizamov).
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to consider the studied parameters of vascular stiffness as surrogate markers to assess prevalence and progression of atherosclerosis, as well as the effectiveness of pharmacological interventions.

Introduction

In recent years, scientific studies have revealed strong evidence for the role of increased stiffness of vascular wall in progression of hypertension and development of its major complications. For example, a correlation between increased vascular wall stiffness (measured based on the pulse wave velocity – PWV) and mortality rate was established in patients with hypertension in the REASON study [1]. The ASCOT-CAFE large-scale study [2] showed that the effect of antihypertensive therapy on the prognosis of patients with hypertension for a comparable decrease in brachial blood pressure (BP) depends on the degree of central aortic pressure reduction, which is modulated by elastic properties of large arteries.

According to the Framingham's criteria, PWV can be even stronger predictor of fatal and nonfatal cardiovascular complications than smoking, blood glucose, total cholesterol and other biological markers [3]. For the first time, in European (2007) and Russian (2008) recommendations on diagnosis and treatment of hypertension, vascular wall was identified as a ''target organ'' of the hypertensive process and increased PWV was included in the list of criteria for subclinical target organ damage in patients with hypertension. This indicator remained in the revised European recommendations on diagnosis and treatment of hypertension adopted in 2013 [4], where the carotid-femoral PWV was identified as an indicator influencing the prognosis of patients with hypertension.

However, the value of the vascular wall stiffness index in patients with coronary heart disease (CHD), depending on the severity of the disease and the intensity of atherosclerosis is the least studied topic.

Objective: to study stiffness of vascular wall in patients with CHD depending on the prevalence of atherosclerotic lesion.

Materials and methods

The main group included 90 patients (54 men and 36 women) aged between 42 and 71 received by the coronary artery disease department of the Republican Specialized Center for Cardiology in 2015 with unstable angina (progressive angina II B class). The CHD diagnosis was confirmed by the results of veloergometry and coronary angiography (CAG). In addition, the study included 27 volunteers (15 men and 12 women) with the excluded cardiovascular disease, who were presented as a control group. The patients of the main group were divided into 3 subgroups: subgroup A included patients with isolated coronary artery disease; subgroup B – patients with bifocal atherosclerosis: a combined lesion in the coronary and carotid arteries, or coronary and femoral arteries; subgroup C represented patients with multifocal atherosclerotic process in which damage was detected in the three basins of the cardiovascular system (CVS): carotid, coronary and femoral arteries.

The vascular wall stiffness was studied based on the examination of the central systolic blood pressure (cSBP), central diastolic blood pressure (cDBP), central pulse pressure (cPP), aortic augmentation (AA), augmentation index (AIx), pulse wave velocity (PWV) by using the applanation tonometry and by means of the SphygmoCor equipment (AtCor Medical, Australia).

Applanation tonometry was performed on a patient in the lying position after a 10-min rest. The patient's passport data, anthropometric data, SBP and DBP measured manually by tonometry were entered into the computer software. The sensor of applanation tonometer was mounted on a radial artery and pulse wave was recorded to obtain high-quality recording with a minimal duration of 10 s, followed by automatic calculations to determine the parameters of central hemodynamics. In order to estimate the PWV, the distance (expressed in mm) from the pulse of the femoral artery to the clavicle (distal distance) and the distance (expressed in mm) from the pulse of the carotid artery to the clavicle (proximal distance) was measured. Consequently, three ECG electrodes were applied on the upper limbs and the left foot, pulse wave was consistently recorded at the carotid and femoral arteries with simultaneous ECG recording, and the PWVs were automatically calculated.

Ultrasonography of the carotid arteries was performed by means of the ALOKA – Multi View (Japan) ultrasound systems equipped with 7 MHz linear sensor [20 m] and SONOLINE VERSA PRO (SIEMENS, Germany). Images of the common carotid arteries (CCA) were obtained from the both sides in real time in synchronization with the R-wave of the ECG. During the sonography of the carotid arteries, thickness of the intima-media (IMT) posterior wall of the distal one-third of the CCA on both sides was estimated with the calculation of the maximal thickness of the IMT for 10-mm part proximal to the bifurcation, and size of atherosclerosis plaque with determination of stenosis percentage (%) by the diameter of the CCA.

Coronary angiography was performed on the Allura CV-20 (Philips, The Netherlands) unit. In order to assess the degree of arterial stenosis, the following characteristics, like: normal coronary artery, abnormal artery contouring without determining the degree of stenosis, stenosis of <50%, stenosis of 51–75%, 76–95%, 95–99% (subtotal) and 100% (occlusion) were visually examined. Hemodynamically significant (>50%) and non-significant coronary artery stenosis <50% cases were considered to be atherosclerotic lesions.

Femoral arteries involvement was evaluated based on the ankle-brachial index (ABI) of less than 0.9. In case of doubt, patients underwent ultrasound duplex scanning. According to recommendations of the European Society of Cardiology, ABI

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