CARDIOVASCULAR REMODELING IN PATIENTS WITH HYPERTENSION WITH DIFFERENT DEGREES OF COGNITIVE IMPAIRMENT

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ABSTRACT

Introduction: Recently, the concept of vascular cognitive impairment, combining all variants of cognitive decline due to cerebrovascular insufficiency, is actively being developed. This concept goes far beyond traditionally existing ideas about the problem of vascular cognitive disturbances [4]. Arterial hypertension (AHT) and atherosclerosis are the main causes of vascular brain damage, leading not only to acute cerebrovascular accidents, but also to chronic progressive brain damage, impairment of cognition being one of its major symptoms [5, 6]. Hypertension is considered to be a risk factor not only for stroke but also for memory troubles and impaired cognitive functions, representing one of the most common abnormalities in elderly and senile individuals [1, 7, 8].

The magnitude of cerebral blood flow is directly proportional to perfusion pressure, which is determined by the resistance to perfusion pressure, which is determined by the arterial blood pressure and its variability [7, 8]. The resistance to perfusion pressure, which is determined by the structural and functional rearrangement of the cardiovascular system and the state of intellectual-nomencal functions in patients with hypertension.

Materials and methods: A comprehensive survey of 146 patients with hypertension of the II and III stage according to ESH / ESC 2013, 2017, 2018 has been performed. The study included patients with mild and moderate cognitive impairment (CI). Depending on the state of the cognitive sphere and on the basis of the results of the neuron-physiological testing, the patients were divided into 3 groups depending on the state of the cognitive sphere and on the basis of the results of the neuron-physiological testing with further comparisons of their clinical and instrumental data.

Results: According to the results of our study, it has been found that an increase of the signs of cardiovascular remodeling was observed in patients with more pronounced changes in cognitive activity. The analysis of intracardiac hemodynamic parameters in patients of the studied groups revealed more significant pathological changes in patients with cognitive impairments than in patients without them. Patients with mild and moderate CI had significantly higher heart rates, left ventricular wall thickness (LV) which led to impairment of the diastolic function of LV and had already been registered in patients without cognitive dysfunction. Moreover, it increased with the appearance (mild) and growth of the degree (moderate) cognitive impairment. The average daily values of BP (SBP, DBP) in patients of all studied groups significantly exceeded the recommended norms, while in patients with moderate CI these rates were significantly higher than those in the group with mild CI (p = 0.028). In addition, the variability of systolic blood pressure was increasing simultaneously with the deterioration of cognitive function of our patients. Also, signs of remodeling were being observed during the study of the state of peripheral vessels (increase of peripheral resistance, pulsation index, linear velocity and thickening of the intima-media complex), which is the main cause of cognitive impairment and causes their appearance and reflects their degree.

Conclusions: The presented study revealed a clear correlation between the degree of cognitive impairment and the degree of changes in the daily blood pressure profile, the most important of which were the average daily systolic blood pressure and systolic blood pressure variability.

On the basis of the conducted research, in the future it will be possible to predict the level of the cognitive sphere involvement, depending on the state of the daily blood pressure profile, changes of the ventricle and vessels geometry, which will enable timely diagnosis of cognitive impairment and the prescription an adequate therapy.

KEY WORDS: cardiovascular remodeling, cognitive impairment, antihypertensive therapy

INTRODUCTION

Over the last decades hypertensive and ischemic heart diseases have become the worldwide epidemic, being risk factors for the development of cerebrovascular complications [1, 2]. According to epidemiological data, at least 50% of people over 55 complain of decreased memorization ability [3]. Moreover, 1% of them progress to dementia during one year, and 12-42% - within 1-5 years [4].

Recently, the concept of vascular cognitive impairment (CI), combining all variants of cognitive decline due to cerebrovascular insufficiency, is actively being developed. This concept goes far beyond traditionally existing ideas about the problem of vascular cognitive disturbances [4].
and intracranial pressure. High instability and variability of blood pressure, high pulse pressure, frequent hypertensive crises, and, consequently, chronic uncontrolled arterial hypertension are the main factors leading to the development of multiple severe disturbances in cerebral vessels [9, 10, 11].

In patients with hypertension neuropsychological tests demonstrate decreased cognitive function as compared to individuals with normal blood pressure (BP) [12, 13, 14, 15, 16].

Structural and functional changes of vessels in AHT are independent causes of cardiovascular complications and adverse prognosis. Development of vascular remodeling is determined by interaction between components of hemodynamic load and activation of neurohumoral systems related to inherited predisposition of polygenic nature [7, 17, 18, 19].

In long-term hypertension, multiple structural and functional changes in the heart and vessels develop, reflecting both compensation mechanisms of hemodynamic disorders and their pathological changes [17, 20]. Myocardial remodeling develops already at the earliest stages of cardiovascular disease continuum, being one of independent risk factors for cardiovascular morbidity and mortality [15, 21]. According to Y.N. Belenkov (2002), remodeling of the left ventricle (LV) implies its structural and geometrical changes, including hypertrophy and dilatation processes, which lead to changes in geometry, sphericity as well as systolic and diastolic dysfunction.

Morphological changes in LV remodeling process - activation of certain genome units, molecular, cellular and interstitial changes - occur at all levels of structural organization of the heart. Cardiac remodeling leads to the development of heart failure, increased electrical instability of myocardium and, consequently, the development of fatal arrhythmias as well as significantly increased risk of cardiovascular mortality [8, 15, 22]. Processes occurring in blood vessels are similar to those in heart muscle: hypertrophy of smooth muscle cells, increase in fibroblast number, collagen structure changes with resultant thickening of all vessel wall layers, increased stiffness and rigidity, endothelial dysfunction and atherosclerotic lesion [9, 10, 11, 23]. Remodeling of cerebral blood vessels causes the damage of brain as a target organ in hypertension. Chronic decrease of cerebral perfusion as a result of both ischemic and hypertensive diseases results in cognitive disorders, their severity determining the patients’ social adaptation and quality of life [17, 24, 25, 26]. Considering the similarity of pathological processes occurring both in heart vessels and cerebral and peripheral blood vessels in cardiovascular disease (in the context of understanding of cardiovascular disease continuum), it is reasonable to suggest the existence of certain correlations between the processes of cardiovascular remodeling and their direct consequences - cognitive impairment.

**THE AIM**

The aim of the work is to study parameters of cardiovascular remodeling in the patients with hypertension depending on the presence of cognitive impairment and the degree of their severity.

**MATERIALS AND METHODS**

146 patients with hypertension (HT) took part in the study. 100 patients (68.5%) had HT of the second stage and 46 patients (31.5%) had the third stage, besides, in the history of 20 (13.7%) of them there was a sharp violation of cerebral circulation and in 18 (12.3%) patients had myocardial infarction. Heart failure (HF) of stage I was diagnosed in 87 patients (59.6%), HF of stage III was diagnosed in patients (31.5%) in 46 patients and 14 (9.6%) had no HF symptoms. The average age was 53.4 ± 0.9 years.

The study did not include patients with a «fresh» stroke (not less than 6 months), craniocerebral trauma, severe renal and liver disorders, HF and the III stage, with existing hereditary diseases with a clinical picture of intellectual disorder, with symptoms of the II and III of dementia, as well as patients who have been abusing alcohol, drugs or excessive use of drugs that can provoke cognitive impairment.

The patients with cognitive impairment (CI) of mild and moderate degree were the main criteria for the inclusion into the study. The diagnosis of CI and the determination of its degree were carried out on the basis of generally accepted criteria as the patients were included into the study. The following methods were used: a short scale for assessing the psychological status of the MMSE (according to Folstein et al., 1975) [3, 5] which can be used to diagnose the presence of cognitive impairment, score outcomes in the range of 24 to 30 points and Schults tables to determine the stability of attention, dynamics of efficiency, efficiency of work and degree of development.

The initial blood pressure level and antihypertensive effect of therapy were evaluated using daily blood pressure monitoring (DMBP). Outpatient monitoring of BP was performed using AVRM-04 (“Meditech”, Hungary). The intervals between measurements were 15 minutes from 7.00 to 22.00 and 30 minutes at night - from 22.00 to 7.00. The following indicators were evaluated: the average daily systolic blood pressure (SBP), the average daily diastolic blood pressure (DBP), the time index for the increase of systolic and diastolic blood pressure (TI SBP, TI DBP) - «pressure load», a percentage of measurements from the total amount at which the value of BP exceed «normal» values - in the daytime - 140/90 mm Hg., at night it is 120/80 mm Hg. Accordingly, the daily indexes of BP (TI SBP, TI DBP), the variability of systolic and diastolic blood pressure per day (VBP BP, VBP DBP), respectively, the speed of morning rise (SMR SBP, SMR DBP) from 5 to 10 a.m., which was calculated as the difference between the maximum and the minimum values. The analysis of the DMBP indicators for determining the degree of hypertension was conducted in accordance with the recommendations of the European Union of Cardiologists.

The determination of the morphological and functional state of the vessels was carried out by the duplex scanning
and color Doppler flow mapping in a generally accepted manner [27]. Common, internal and external carotid arteries (CA) were investigated. The artery passage, vascular geometry, the state of the intima-media complex of CA, the presence of changes, their severity and structure, as well as the linear and volumetric speed of blood flow in the common CA (CCA). The vessel diameter (mm), the thickness of intima mediums (IMT) of the vessel (mm), the presence, localization and size (diameter) of atherosclerotic plaques (mm), maximal stenosis of carotid arteries in%, linear velocity of blood flow (V, m / c), pulsation index (PI), index of peripheral resistance (RI) were determined in every patient.

The following echocardiographic parameters were determined for evaluation of the state of the left ventricle: end-diastolic dimensions and volumes with indices determination (iEDV, iESV), the ejection fraction (EF), the interventricular septal thickness (IST) and the posterior wall thickness of the left ventricle in the diastole (LVP-WTd). With the same purpose the relative wall thickness (RWT) and the heart beat index (IB) using the standard calculation methods, the transverse size of the left atrium with the definition of the index (iLA) and the index of the myocardial mass of the left ventricle (iLVMM) were calculated.

Left ventricle diastolic function was evaluated according to the pulsed Doppler echocardiography. The following indices of transmitial blood flow were determined: the maximum velocity of early diastolic filling (VE), late diastolic filling (VA) and their ratio (VE / VA), the retardation time of early diastolic filling (Tdec) and the isovolumic relaxation time (IVRT).

The patients were divided into 3 groups depending on the state of the cognitive sphere and on the basis of the neuron-psychological testing results. The first group of 30 patients with HT who did not have signs of cognitive impairment were included in the study as a «comparison group». The second one included 78 patients (53.4%) who had mild cognitive impairment (MCI), the third group - 38 patients (26%) with moderate cognitive impairment (MCI) [14].

Statistical processing of the study results was conducted using the variation statistics method and the program StatSoft «Statistica» v. 6.0 due to the recommendations [28]. The obtained results were presented: 1) quantitative values - in the form of median and interquartile scale (25 and 75 percentiles); and 2) relative values (reflecting the sign frequency in the sample) in the form of percentages (%). The indicator dynamics against the background of treatment was presented as a percentage of indicators in%, which was calculated according to the formula - indicator increment (%) = [(initial value - value after the treatment) / value after the treatment] · 100%.

RESULTS AND DISCUSSION
The analysis of the parameters of intracardiac hemodynamics in patients of the studied groups revealed more significant pathological changes in patients with cognitive impairment (the 2nd and 3rd groups) than in patients without them (group 1 (Table I)). Patients with mild and moderate CI had significantly higher heart rates, which was manifested in relatively large indexes of iEDV (p = 0.040), iESV (p = 0.038), and iLA (p = 0.048). These indicators clearly highlighted the presence of the heart remodeling in patients with cognitive impairment. Interestingly, these rates were significantly higher in patients with moderate cognitive impairment than in patients with mild changes in intellectual-mnemonic activity. That is, in these patients the degree of remodeling of both LV and LA was increasing simultaneously with cognitive changes. These changes were confirmed by the existence of close correlations between iLA and iEDV and the degree of cognitive impairment (p <0.0001). The changes of the size and volume of the left ventricular cavities were accompanied by changes of the wall thickness of the lungs in patients with HT with varying degrees of cognitive impairment: the WT score was significantly higher in patients with moderate CI than in patients with mild CI (p = 0.011), which also indicates on a more significant remodeling of LV in patients with more severe cognitive dysfunction.

The increase of the left ventricular cavity size and thickening of its walls in patients with HT resulted in a disturbance of the diastolic function of LV, which was already registered in patients without cognitive dysfunction and was increasing due to the appearance (mild) and increased degree of cognitive impairment (moderate) (Table I). These particular changes were presented by the time parameters of transmitial blood flow which characterize diastole (iVRT and Tdec).

The ratio of the rate of early and late diastolic filling E / A became reliable only while comparing the 2nd and 3rd groups, that is in patients with mild and moderate CI (p = 0.017). There was no significant difference between the study groups in terms of the contractile function of LVEF %, which is probably due to a more significant vascularization of patients with intellectual-mnemonic disorders than to heart muscle damage.

The real picture of the digital values of blood pressure received at DBPM is significantly different from the values of «office» BP at the reception of a doctor, which is confirmed by numerous studies. Therefore, DBPM was performed in order to determine the degree of hypertension to all patients. The average daily values of BP (SBP, DBP) in patients of all studied groups significantly exceeded the recommended norms. Moreover, in patients with moderate CI these rates were significantly higher than those in the group with mild CI (p = 0.028) (Table II). Average indicators of 24-hour monitoring obtained in normal conditions of life clearly correlate with organ effects such as acute (stroke, heart attack) and chronic (cognitive dysfunction, cardiac remodeling and vessel nephropathy, retinopathy) [6, 7, 9, 29] . Thus, in our study, we found close correlations between the daily average systolic blood pressure and the severity of cognitive impairment (p = 0.041).

Many systems of the body participate in the formation of the variability of BP (VAR SBP, VAR DBP), though the
A dominant role is given to the central nervous mechanisms, that is to the daily periodicity of excitation and inhibition in the cerebral cortex. The variability of the general peripheral blood vessel resistance, cardiac output, heart rate plays the role in the formation of fluctuations of blood pressure at the systemic level. At the regional level it is a change in the need for blood supply to the brain and other organs during the day. At the molecular level, the variability of blood pressure is influenced by circadian activity of baro- and chemoreceptors, alpha and, especially, beta adrenergic receptors. In 75% of patients with HT there is an increased VAR of BP at night, which decreases with the progression of the disease and the involvement of target organs. Investigating the role of BP variability, it has been shown that the increase in VAR BP has a strong correlation with the severity of BP, the early development of left ventricular hypertrophy and its diastolic dysfunction, as well as the retinopathy and angiopathy of vessels of the brain that is the

Table I. Echocardiographic parameters in patients with hypertension and different degrees of cognitive impairment

<table>
<thead>
<tr>
<th>Index</th>
<th>1st group (No CI)</th>
<th>2nd group (light CI)</th>
<th>3rd group (moderate CI)</th>
<th>P1-2</th>
<th>P1-3</th>
<th>P2-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILV mm / m2</td>
<td>20,5 (19,0; 23,0)</td>
<td>21,0 (19,0; 23,5)</td>
<td>23,2 (22,0; 26,6)</td>
<td>0,37</td>
<td>0,037</td>
<td>0,048</td>
</tr>
<tr>
<td>iEDV, ml / m2</td>
<td>65,7 (58,0; 85,3)</td>
<td>63,0 (54,0; 75,0)</td>
<td>59,7 (54,0; 72,0)</td>
<td>0,21</td>
<td>0,025</td>
<td>0,04</td>
</tr>
<tr>
<td>iESV, ml / m2</td>
<td>30,0 (21,0; 35,0)</td>
<td>27,0 (21,0; 33,0)</td>
<td>25,5 (20,0; 29,5)</td>
<td>0,38</td>
<td>0,023</td>
<td>0,038</td>
</tr>
<tr>
<td>iHB, ml / m2</td>
<td>33,4 (29,0; 41,0)</td>
<td>36,0 (30,0; 42,0)</td>
<td>35,0 (27,3; 42,4)</td>
<td>0,79</td>
<td>0,68</td>
<td>0,61</td>
</tr>
<tr>
<td>EF, %</td>
<td>56,8 (52,7; 71,0)</td>
<td>55,6 (49,7; 64,4)</td>
<td>58,5 (50,0; 64,0)</td>
<td>0,26</td>
<td>0,61</td>
<td>0,36</td>
</tr>
<tr>
<td>LVPWTd, mm</td>
<td>12,0 (11,0; 13,0)</td>
<td>12,0 (11,0; 13,0)</td>
<td>12,1 (11,3; 13,0)</td>
<td>0,89</td>
<td>0,77</td>
<td>0,43</td>
</tr>
<tr>
<td>IVSTd, mm</td>
<td>13,0 (11,0; 13,0)</td>
<td>12,0 (11,0; 13,0)</td>
<td>12,4 (12,0; 13,6)</td>
<td>0,67</td>
<td>0,59</td>
<td>0,43</td>
</tr>
</tbody>
</table>

Notes: the data of quantitative indicators are presented as M ± m - the average value is the mathematical error of the average and as Med (per25; per75) - the median and interquartile scale (25 and 75 percentiles).

Table II. DBPM indices in patients with hypertension and various degrees of cognitive impairment.

<table>
<thead>
<tr>
<th>Index</th>
<th>1st group (No CI)</th>
<th>2nd group (light CI)</th>
<th>3rd group (moderate CI)</th>
<th>P1-2</th>
<th>P1-3</th>
<th>P2-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP, mm Hg</td>
<td>142,0 (125,0; 150,0)</td>
<td>144,0 (136,0; 160,0)</td>
<td>151,0 (136,0; 172,0)</td>
<td>0,42</td>
<td>0,011</td>
<td>0,028</td>
</tr>
<tr>
<td>DBP, mm Hg</td>
<td>82,0 (74,0; 91,0)</td>
<td>84,9 (76,7; 92,0)</td>
<td>89,5 (78,0; 97,1)</td>
<td>0,3</td>
<td>0,02</td>
<td>0,028</td>
</tr>
<tr>
<td>TI SBP, %</td>
<td>26,5 (16,0; 40,0)</td>
<td>33,0 (27,0; 51,0)</td>
<td>38,5 (22,0; 51,0)</td>
<td>0,026</td>
<td>0,039</td>
<td>0,017</td>
</tr>
<tr>
<td>TI DBP, %</td>
<td>18,0 (12,0; 30,0)</td>
<td>19,5 (14,0; 36,0)</td>
<td>28,0 (7,0; 41,0)</td>
<td>0,09</td>
<td>0,007</td>
<td>0,012</td>
</tr>
<tr>
<td>VAR SBP, mm Hg</td>
<td>14,5 (12,5; 18,0)</td>
<td>15,9 (14,2; 20,0)</td>
<td>17,4 (12,5; 25,1)</td>
<td>0,014</td>
<td>0,0007</td>
<td>0,005</td>
</tr>
<tr>
<td>VAR DBP, mm Hg</td>
<td>12,6 (9,9; 15,0)</td>
<td>12,1 (9,9; 15,2)</td>
<td>13,7 (11,9; 16,9)</td>
<td>0,21</td>
<td>0,09</td>
<td>0,18</td>
</tr>
<tr>
<td>SMR SBP, mm Hg</td>
<td>10,0 (7,0; 15,0)</td>
<td>10,5 (7,0; 14,0)</td>
<td>14,5 (10,0; 19,0)</td>
<td>0,74</td>
<td>0,018</td>
<td>0,031</td>
</tr>
<tr>
<td>SMR DBP, mm Hg</td>
<td>10,0 (6,0; 14,2)</td>
<td>9,0 (5,0; 13,0)</td>
<td>10,0 (6,0; 14,0)</td>
<td>0,23</td>
<td>0,85</td>
<td>0,52</td>
</tr>
<tr>
<td>DI SBP, %</td>
<td>8,6 (5,5; 12,0)</td>
<td>8,2 (3,7; 12,2)</td>
<td>8,3 (4,4; 11,9)</td>
<td>0,84</td>
<td>0,68</td>
<td>0,91</td>
</tr>
<tr>
<td>DI DBP, %</td>
<td>13,5 (8,0; 15,7)</td>
<td>12,3 (9,8; 16,5)</td>
<td>11,4 (8,9; 13,0)</td>
<td>0,16</td>
<td>0,044</td>
<td>0,08</td>
</tr>
</tbody>
</table>

Notes: the data of quantitative indicators are presented as M ± m - the average value is the mathematical error of the average and as Med (per25; per75) - the median and interquartile scale (25 and 75 percentiles).
CI basis [16, 17, 30]. Thus, there is every reason to consider increased VAR SBP as an independent risk of affecting target organs and the development of complications in hypertension. According to the received data, the variability of the systolic blood pressure increased concurrently with the deterioration of the cognitive function. In addition, we have received a close correlation between the degree of CI and VAR SBP (p <0.001).

The increase of the average daily SBP and VAR SBP in patients with cognitive impairments also led to an increase in the time index (IT SBP) in these patients. What is more, the degree of CI growth correlated with the magnitude of IT SBP. The duration of the increase of the blood pressure during the day (IT) characterizes the hyperbaric load on target organs more accurately than the mean values of blood pressure. Numerous studies have shown that the duration of the increase of BP is a more important risk factor for cardiovascular complications: a close correlation between the iLVMM, the maximum left ventricular filling rate and left ventricular index [15, 16, 17, 25, 26] has been established.

The Framingham study, which is considered to be a benchmark for epidemiological studies, has revealed the importance of the early rise of BP in the occurrence of such complications of hypertension as strokes, heart attacks and sudden death, the risk of which was 70% higher in the early hours compared to other periods of the day. According to data of our study, the value of the speed of morning rise (SMR) in patients with the moderate CI was significantly higher than in patients of the first two groups (p = 0.031) (Table II). Thus, the deepening of the daily profile of blood pressure in patients with HT resulted in an increase of cognitive impairment, which can possibly be considered as a brain damage during hypertension.

The combination of elevated blood pressure with atherosclerotic damage of carotid arteries which often coexists and determines the high risk of cardiovascular complications in such patients is particularly unfavourable. There is evidence that even a small amount of their atherosclerotic lesions has the same importance in the development of cerebral complications, as well as hemodynamic–significant stenosis [17, 19, 20].

The index of «intima-media», which is measured during sonography or duplex examination of extracranial vessels, is the most important and the earliest indicator of the development of the atherosclerotic process [19, 20, 31]. The peculiarities of the vascular bed remodeling in patients with coronary artery disease and HT can, in turn, determine the likelihood of the development of cerebrovascular complications in this category of patients [24]. There is information about the correlation between the thickness of intima-media (IMT) and the type of ischemic stroke, the size of the ischemic focus and its localization [29]. It is believed that the more IMT is the higher the probability of stroke. In addition, the absolute magnitude of IMT progressively increases in proportion to the age and the duration of hypertension.

The indices of the pulsation index (Pi) and index of peripheral resistance (Ri), which are indirect evidence of the increase in the value of peripheral resistance of the brain vessels, increased with the extent of the occurrence and growth of violations of the cognitive sphere in the studied groups. In addition, the linear velocity of blood flow in the carotid arteries increased with the same regularity (V, m / s). The mutual growth of vascular resistance and blood flow velocity in them due to vascular remodeling as a result of both excessive pressure and atherosclerosis is the leading pathogenetic mechanism of occurrence of both chronic cerebral hypoperfusion and acute cerebrovascular disorders.

There also were IMT different values in the studied patients with different degrees of cognitive impairment: this rate increased with the increase of these violations with significant differences between all groups (p = 0.005, p = 0.001, p = 0.031). Importantly, if the IMT did not exceed the norm (0.8 mm) in patients without deviations of the cognitive activity, it was already greater than normal (0.92 mm at normal to 0.9 mm) in patients with mild CI and even more (0.95 mm) in patients with moderate cognitive impairment even more (0.95 mm) (Table III). According to the presented study, close correlation between IMT and the degree of cognitive impairment (p <0.0001), as well as between the total number of atherosclerotic

### Table III. The indicators of Doppler study of extracranial vessels in patients with hypertension and different degrees of cognitive impairment

<table>
<thead>
<tr>
<th>Index</th>
<th>1st group (No CI)</th>
<th>2nd group (light CI)</th>
<th>3rd group (moderate CI)</th>
<th>P1-2</th>
<th>P1-3</th>
<th>P2-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>V, m/s</td>
<td>0.70 (0.63; 0.79)</td>
<td>0.77 (0.67; 0.88)</td>
<td>0.82 (0.78; 0.99)</td>
<td>0.012</td>
<td>0.004</td>
<td>0.028</td>
</tr>
<tr>
<td>Ri</td>
<td>0.71 (0.68; 0.73)</td>
<td>0.72 (0.69; 0.75)</td>
<td>0.72 (0.68; 0.76)</td>
<td>0.14</td>
<td>0.08</td>
<td>0.64</td>
</tr>
<tr>
<td>Pi</td>
<td>1.60 (1.34; 1.75)</td>
<td>1.74 (1.49; 1.82)</td>
<td>1.77 (1.58; 1.84)</td>
<td>0.009</td>
<td>0.0007</td>
<td>0.07</td>
</tr>
<tr>
<td>IMT, mm</td>
<td>0.80 (0.80; 1.05)</td>
<td>0.92 (0.84; 1.12)</td>
<td>0.95 (0.90; 1.20)</td>
<td>0.005</td>
<td>0.001</td>
<td>0.031</td>
</tr>
<tr>
<td>Total amount of atherosclerotic plaques</td>
<td>1 (0; 2)</td>
<td>2 (1; 2)</td>
<td>3 (3; 4)</td>
<td>0.14</td>
<td>0.007</td>
<td>0.022</td>
</tr>
<tr>
<td>Frequency of registration of atherosclerotic plaques in %</td>
<td>12 (40,0%)</td>
<td>54 (69,2%)</td>
<td>32 (84,2%)</td>
<td>0.005</td>
<td>&lt;0.0001</td>
<td>0.08</td>
</tr>
<tr>
<td>Maximal stenosis of carotid arteries in %</td>
<td>20 (0; 40)</td>
<td>25 (15; 40)</td>
<td>30 (30; 60)</td>
<td>0.09</td>
<td>0.006</td>
<td>0.01</td>
</tr>
</tbody>
</table>
plaque and maximal stenosis of carotid arteries (p < 0.0001) with the presence and degree of CP have been received.

CONCLUSIONS
1. The current study revealed a clear correlation between the degree of cognitive impairment and the degree of changes in the daily blood pressure profile, the most important of which were the average daily systolic blood pressure and systolic blood pressure variability.
2. The occurrence and degree of cognitive impairment closely correlate with the geometry of the left ventricle, which confirms the existence of a common process of cardiovascular remodeling, the manifestation of which is the hypoperfusion of target organs with the development of their dysfunction.
3. Remodeling of brain vessels due to arterial hypertension and atherosclerosis, determined by the vascular Doppler, is the main cause of cognitive impairment, the appearance and reflects their degree.
On the basis of the conducted research, in the future it will be possible to predict the level of the cognitive sphere involvement, depending on the state of the daily blood pressure profile, changes of the ventricle and vessels geometry, which will enable timely diagnosis of cognitive impairment and the prescription an adequate therapy.

REFERENCES


Authors’ contributions:
According to the order of the Authorship.

Conflict of interest:
The Authors declare no conflict of interest.

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