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The peculiarities of cognitive impairment and their association with structural changes in the carotid artery of the patients after ischemic stroke

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Abstract
This article represents and analyzes data from a study of the state of cognitive function and the role of structural changes of an internal carotid artery wall. The results of the study indicate a significant prevalence of post-stroke cognitive impairment (CI) with the advantage of moderate CI of the patients with the late recovery period of ischemic stroke. The most sensitive diagnostic tool was the MoCA scale, which allowed to detect CI in 90.5% of patients, whereas according to the MMSE and FAB scale there were 83.7% and 72.1% patients accordingly. Stenotic pathology of carotid and vertebral arteries of different localization and degree, deformation of the anatomical move, bending and their sinuation were revealed by duplex scanning of extracranial vessels. Correlation between markers of atherosclerosis and CI manifestation was determined. Early diagnosis of these disorders when choosing drug therapy could increase the effectiveness of preventive strategies and rehabilitation of the patients in this condition and improve their quality of life.

Keywords: ischemic stroke, cognitive impairments, carotid stenosis, intima-media thickness

Introduction
Ischemic stroke (IS) remains the leading cause of disability in the population, which determines the relevance of the issue of rehabilitation of the patients with cerebrovascular pathology. Decrease in lethality after stroke was achieved during the last decade which is accompanied by an increase of prevalence of the post-stroke cognitive impairments (PSCI) [1, 5]. PSCI significantly reduce the quality of patients life, leading to a sustained disadaptation. On the one hand, these disorders are the result of the organic brain damage, and on the other hand it is the reaction which is necessary to adapt to the new life conditions caused by the disease. They have a significant effect on the course of the recovery period and can become a serious obstacle to the adequate rehabilitation of this category of patients. That's why, the state of the cognitive sphere can be considered as a prognostic criterion for the restoration of post-stroke patients. According to the literature data, PSCI of varying degrees are found in 63-76% of the patients after IS, for whom the predominant violation of the executive functions and attention are characteristic [4, 10]. Described so-called "strategic zones", the presence of even isolated necrotic changes leads to the development of cognitive impairments. These sites include an angle gyrus, a knee inner capsule, lower medial parts of temporal particles, medial sections of the frontal lobes, front and dorsomedial thalami, basal ganglia and hippocampus [7]. For an effective diagnosis of PSCI, it is important to choose the optimal technique for the clinical examination. Diagnostic tools in this case are the questionnaires and scales that have shown high sensitivity and specificity in the evaluation of post-stroke cognitive impairments [2, 3, 9]. Considerable attention is paid to the evaluation of the atherosclerotic process in the carotid arteries, which plays an important role in cerebrovascular diseases and cognitive deficits [12]. Carotid atherosclerosis not only affects the subtle general cognitive function but also reduces the specific domains of the cognitive function, such as memory, motor function, visual perception, attention, and executive function. The most informative early marker of an atherosclerosis is an increase of the carotid intima-media thickness (IMT) [1]. One of the mechanisms for the formation of cognitive deficits of the patients with an ischemic stroke may be a reduction in cerebral blood flow and a violation of the neurons function, since the brain tissue is highly sensitive to oxygen and glucose [11]. In the longitudinal, long-term population study of AGES-Reykjavik (2430 elderly people), it has been shown that an increase carotid IMT as an early marker of an atherosclerosis is associated with the decline brain volume and

gray matter according to the magnetic resonance imaging data [8]. At the hemodynamically significant extensions and bends of the extracranial divisions of the internal carotid arteries (ICA) atrophic changes occur in the adjacent blood supply zones in the frontal and parietal-temporal brain regions and often the repeated cerebral circulation disorders [5]. Knowledge of these issues is very important in modern angioneurology to develop a strategy for treating such patients and secondary prevention.

The aim of the study: to identify and assess the severity of cognitive impairments and their association with the structural changes of an internal carotid artery of the patients with a late recovery period of ischemic stroke.

Materials and Methods

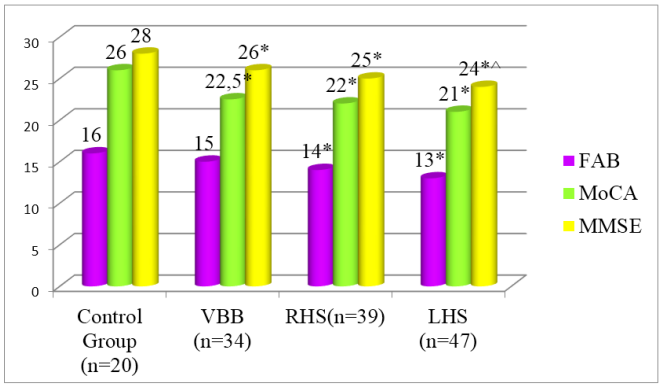
120 patients with ischemic stroke (80 men and 40 women with an average age of 55 [51; 61]) were observed. All patients were divided into two main groups: 1 – 86 patients with hemispheric IS and 2 – patients with IS in the vertebro-basilar basin (VBB). The control group included 20 practically healthy individuals without any signs of a cerebrovascular pathology. There were 85 (70.8%) patients who were diagnosed with atherothrombotic IS, 25 (20.8%) patients who were diagnosed with cardioembolic IS and lacunar IS was observed in 10 (8.3%) cases. Left-hemispheric stroke (LHS) was diagnosed in 39% examined patients, right-hemispheric stroke (RHS) – in 33% and IS in the VBB – in 28% cases.

The inclusion criteria for the study were late recovery period of ischemic stroke in the middle cerebral artery basin and vertebra-basilar basin (after 6 months past IS). The exlusion criteria were reccurent stroke, sensory aphasia, severe somatic pathology, symptomatic epilepsy. The control group included 20 practically healthy individuals without any signs of the cerebrovascular pathology. The median age was 50.

For the examination of cognitive functions, the Mini-Mental State Examination (MMSE), the Montreal Cognitive Scale (MoCA), Frontal Assessment Battery (FAB) and the Clock-Drawing Test (CDT) were used according to generally accepted techniques [2, 3, 9]. Ultrasonic duplex scanning of the extracranial ICA was performed using the Esaote My Lab 30 (Italy) apparatus according to the generally accepted method [40] to assess intima-media thickness and the stenosis degree by diameter. Stenosis <50% of the lumen were evaluated as hemodynamically insignificant (mild), 50-70% – as moderate, 70-99% – as severe, 100% – as vessel occlusion [6]. Statistical analysis of the received results was performed using statistical methods of analysis with STATISTICA (StatSoft, Inc.) and MS Excel. There were used nonparametric methods: median (Me) and interquartile interval [Q25%; Q75%] was calculated, the Mann-Whitney U test was used to assess a statistically significant difference between groups. Correlation analysis was performed using Spearman correlation coefficient.

Results and Discussion

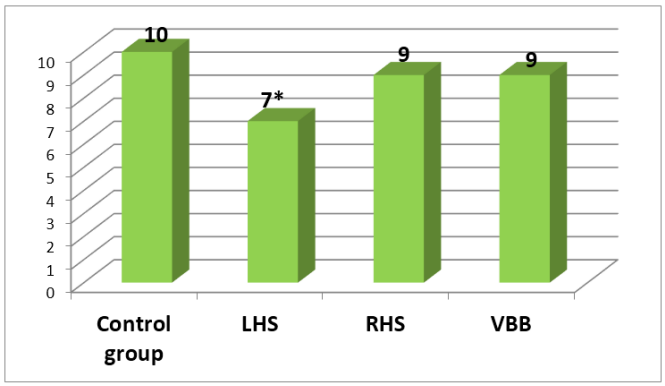
According to the MMSE scale cognitive deficits were observed in 106 (88.3%) patients, the MoCA – in 109 (90.8%) and the FAB – in 94 (78.3%) patients. The median CI score for all scales of the patients of both groups was significantly lower ($p<0.05$) compared to the control group (Fig. 1), while the patients with LHS had significantly lower ($p<0.05$) assessment than for control group and compared to patients with RHS and VBB stroke ($p <0.05$).



Notes: * - significant difference compared to the control group ($p<0.05$); ^ - significant difference compared to Group of patients with IS in the VBB ($p<0.05$).

Fig 1: The Status of Cognitive Functions of the Patients with Ischemic Stroke According to the Location Focus

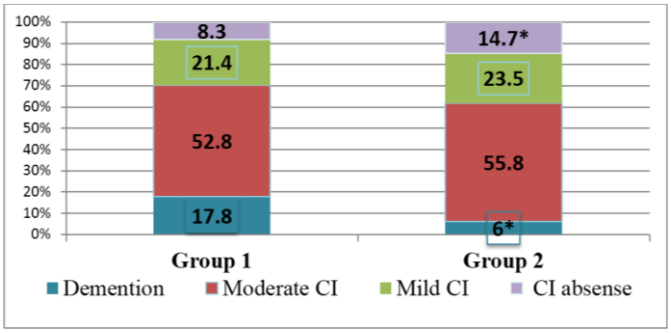
When CDT was performed with patients with LHS, minor inaccuracies were found at the arrows placement, which corresponded to 7 points compared to the control group with 10 [10; 10] points.



Note: * - significant difference compared to the control group ($p<0.05$)

Fig 2: Clock-Drawing Test of the Patients with Ischemic Stroke

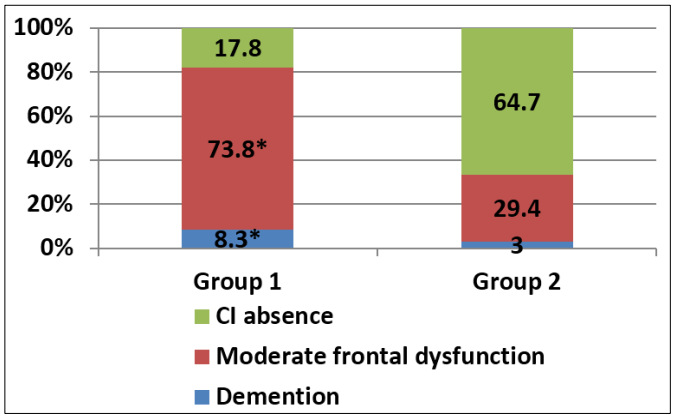
According to the MMSE scale patients with moderate CI dominated in the structure of both main groups. The patients of Group 2 had the percentage of persons with CI absence (14.7%), it was significantly higher ($p <0.05$) versus 8.3% of Group 1, and the share of patients with mild dementia 6% was lower ($p<0.05$) compared to 17.6% of patients of Group 1 (Fig. 2).



Note: * - significant difference compared to the Group 1 ($p<0.05$)

Fig 3: Distribution of patients on the degree of cognitive impairment according to the MMSE scale

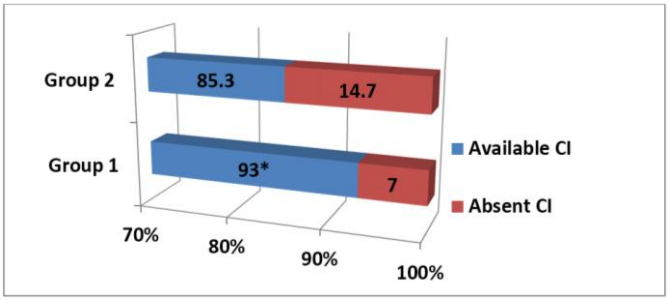
According to the FAB scale persons with moderate frontal dysfunction prevalented (73.8%) of the patients structure, but the share of patients with no CI (17.8%) of Group 1 was significantly lower (p<0.05) compared to the Group 2 (64.7%) (Fig.4).



Note: * - significant difference compared to the Group 2 (p<0.05)

Fig 4: Distribution of patients on the degree of cognitive impairment according to the FAB scale

According to the MoCA scale the share of patients with absent (7.0%) and available CI (93.0%) of the Group 1 was significantly different (p<0.05) from the Group 2 parameters (14.7% and 85.3% accordingly) (Fig. 4).



Note: * - significant difference compared to the Group 2 (p<0.05)

Fig 5: Distribution of patients on the degree of cognitive impairment according to the MoCA scale

The results of extracranial vessels duplex scanning revealed the stenotic pathology of carotid arteries of different localization and degree, deformation of the anatomical move, bending and their sinuosity. Among the examined patients 66 (55%) had such endovascular formations as atherosclerotic plaques. The stenting process in ICA is represented by the stenoses of varying degrees of severity according to the NASCET criteria [6]. Low-degree stenosis (0% to 40%) was diagnosed in 34 (28.3%) patients, moderate stenosis (50% to 70%) - in 23 (19.1%). Hemodynamically relevant stenosis (more than 70%) was noted in 4 (3.3%) patients. ICA occlusion was detected in 2 (1.6%) patients. 10 (8.3%) patients had S-shaped and 9 (7.5%) C-shaped bends of ICA.

We noted that a higher degree of carotid stenosis corresponded to a greater ICA intima-media thickness

Table 1: Intima-media thickness indicators depending on the carotid stenosis degree

Stenosis degree (%)	n	%	Median IMT, mm
30-50%	51	42.5	0.91[0.86; 1.24]
50-70%	6	5	1.46 [1.19; 1.73]
70-90%	4	3.3	2.07 [1.21; 2.51]

The degree of ICA stenosis was significantly correlated with CI manifestations according to the Clock-Drawing Test (r = -0.35; p=0.025). The increase in carotid IMT (ICA) was associated with the cognitive impairment according to the FAB scale (r=-0.33; p=0.035), which indicates that frontal memories functions depend on early atherosclerotic changes in the major vessels of the carotid basin. These data correspond to the results of other studies [11-12]. CI are connected with a decrease in cerebral blood supply, a decrease in oxygenation, and, consequently, a decrease in neurons functional activity and a gradual development of the cerebral cortex atrophy [8].

The results of our study show that patients with excessive values of carotid artery IMT require more intensive monitoring. Therefore, for the purpose of early detection of the cognitive dysfunction, it is necessary to start testing for the state of the cognitive functions of patients with increased values of the IMT (0.9-1.3 mm) of the carotid artery.

Conclusion

1. The results of the study indicate a significant prevalence of PSCI with the advantage of moderate CI of the patients with the late recovery period of IS. It should be noted that in this case, the most sensitive diagnostic tool was the MoCA scale, which allowed to detect CI in 90.5% of patients, whereas according to the MMSE and FAB scale there were 83.7% and 72.1% patients accordingly. CI in the examined contingent of patients were manifested mainly by disturbances of concentration, attention, praxis, memory and executive functions.
2. Increase in carotid IMT was associated with deterioration of cognitive functions for FAB (r = -0.33; p = 0.035). Carotid atherosclerosis can be used to predict the risk of the cognitive impairment. Furthermore, diagnosing and treating carotid atherosclerosis at an early stage may help clinicians to prevent and treat vascular cognitive impairment of the nonstroke patients.
3. The presence of cognitive impairments makes a significant contribution to the disability of patients with the ischemic stroke. Taking it into consideration, it is necessarily to establish the degree of the cognitive deficits after a stroke, in order to plan further rehabilitation, preventive and curative measures.

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