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The State of the Autoregulation System of Cerebral Circulation in Patients who have Suffered A Hemispheric Stroke

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ABSTRACT
This study examines the state of the autoregulation system of cerebral circulation in patients who have suffered a hemispheric stroke. It analyzes changes in cerebral blood flow, focusing on significant alterations in the velocity and volume of blood flow in major arteries, such as the internal carotid and vertebral arteries. The findings indicate distinct differences in cerebral circulation between patients, with notable impairments in autoregulation among those with severe stroke symptoms. The results underscore the importance of assessing cerebral autoregulation to guide treatment strategies and improve outcomes in stroke rehabilitation.

Keywords: Autoregulation, Cerebral Circulation, Hemispheric Stroke, Cerebral Blood Flow, Internal Carotid Artery, Vertebral Artery, Stroke Rehabilitation, Blood Flow Velocity, Cerebrovascular Disorders.

1. INTRODUCTION

Ischemic stroke (IS) is one of the leading causes of death and disability worldwide. According to the World Health Organization, about 15 million cases of stroke are registered annually, of which about 5 million are fatal, and another 5 million lead to permanent disability. Hemispheric stroke, which affects one of the hemispheres of the brain, is often accompanied by severe neurological deficit, impairment of motor, cognitive and speech functions, which significantly reduces the quality of life of patients and requires long-term rehabilitation.

One of the key factors determining the outcome of a stroke is the state of the autoregulation system of cerebral circulation. Autoregulation ensures the maintenance of stable cerebral blood flow during changes in systemic arterial pressure, which is necessary to ensure adequate delivery of oxygen and nutrients to neurons. Impaired autoregulation can lead to deterioration of cerebral perfusion, an increase in the ischemic zone and aggravation of neurological deficit[3].

Transient ischemic attacks (TIAs) are short-term episodes of cerebrovascular accidents accompanied by transient neurological symptoms. TIAs are considered as predictors of the development of ischemic stroke and indicate the presence of pathological changes in the vascular system of the brain. A history of TIAs may indicate a violation of autoregulation mechanisms and an increased risk of severe stroke[5].

Despite significant progress in understanding the pathophysiology of stroke, issues related to the impact of previous TIAs on the state of the cerebral circulation autoregulation system in the acute period of ischemic stroke remain poorly understood. The study of these aspects is important for the development of personalized approaches to treatment and rehabilitation, as well as for predicting disease outcomes.

The aim of this study is to evaluate the state of the cerebral circulation autoregulation system in patients who have suffered a hemispheric stroke, taking into account the presence or absence of a history of TIAs. We assume that in patients with previous TIAs, autoregulation disorders are more pronounced, which may affect the severity of neurological deficit and functional outcomes.

2. Study Material

The study included 74 patients in the acute period of the first acute cerebrovascular accident (CVA) in the carotid basin. The patients were divided into two groups. Group I consisted of 40 patients with a history of TIAs, aged 40 to 65 years (mean age 53.0±6.0 years). There were 55% men (22 patients), 45% women (18 patients). Group II included 34 patients without a history of TIAs, aged 40 to 65 years (mean age 52.0±7.0 years). Men accounted for 53% (18 patients), women — 47% (16 patients) (Table 1).

Table 1: Distribution of patients by gender

Indicator	Group I (n=40)		Group II (n=34)		TOTAL(n=74)	
	abs	%	abs	%		%
Man	22	55,00	18	52,94	40	54,05
Female	18	45,00	16	47,06	34	45,95
Total	40	54,05	34	45,95	74	100,00

The average age of patients in both groups was comparable, which excludes the influence of the age factor on the results of the study. The distribution by gender between the groups was almost uniform, which allows comparing the groups without taking into account gender differences. The control group consisted of 20 relatively healthy individuals, comparable in gender and age with the main groups.

3. RESEARCH METHODS

Neurological status was assessed using the National Institutes of Health Stroke Scale (NIHSS), modified Rankin Scale, and Rivermead Mobility Index. General and biochemical blood tests were performed to assess the general condition and identify possible metabolic disorders. Computed tomography (CT) of the brain was performed to visualize the ischemic focus. Ultrasound duplex scanning of the brachiocephalic vessels was used to assess the condition of the extracranial arteries. The Glasgow Coma Scale was used to assess the level of consciousness. Evaluation of the autoregulatory system of cerebral circulation: was performed using transcranial Doppler sonography (TCDG) in combination with functional tests.

Statistical methods: Data are presented as mean (M) and standard deviation (σ). Student's t-test was used to compare groups. A $p<0.05$ value was considered statistically significant. Correlation analysis was used to identify relationships between autoregulation parameters and clinical data.

4. RESEARCH RESULTS

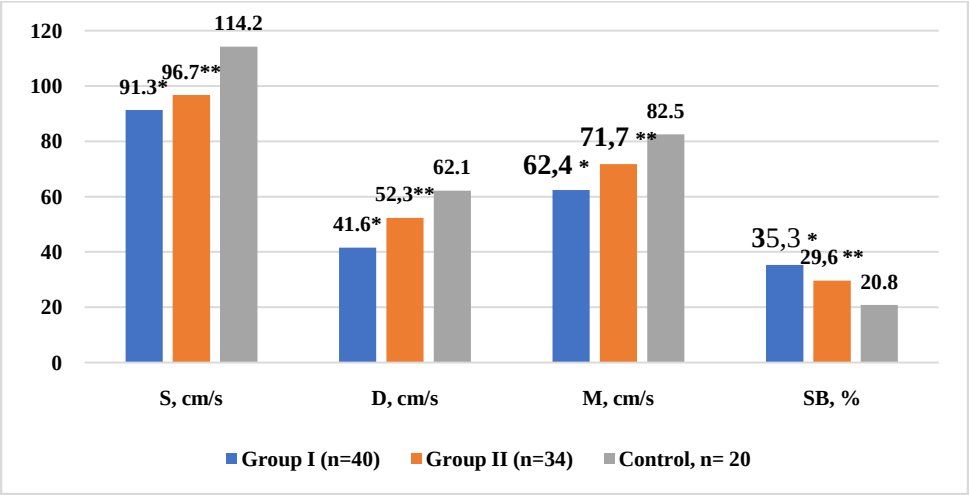
According to the NIHSS scale, patients in Group I had a higher average score (12.0±3.0) compared to Group II (10.0±4.0), which indicates a more severe neurological deficit. According to the Rankin scale, a higher score was found in Group I (3.0±1.0), which indicates a greater degree of disability. Also, the Rivermead index showed lower values in Group I (10.0±2.0), which reflects a decrease in mobility in these patients (Table 2).

Table 2: Indicators of the neurological status of patients

Indicator	Group I (n=40)	Group II (n=34)	p=
Average NIHSS score	12,3 ± 3,6	10,5 ± 4,1	0,023*
Average Rankin Scale score	3,7 ± 1,4	2,4 ± 1,7	0,015*
Rivermead Mobility Index	10,3 ± 2,6	12,3 ± 3,2	0,032*

Doppler ultrasound showed significant differences in blood flow parameters between the two groups. Patients with previous TIAs had a decrease in blood flow velocity in the common carotid artery (CCA) after compression compared to the group without TIAs ($p<0.05$). The average blood flow velocity (ABC) was 42.3±8.1 cm/s in Group I and 50.5±10.2 cm/s in Group II ($p<0.01$).

It was also found that the first group of patients significantly more often had pathologies associated with impaired vasomotor function, such as endothelial dysfunction and slow recovery processes after compression, which is confirmed by lower values of the resistive index (RI) and increased vascular reactivity ($p<0.05$).



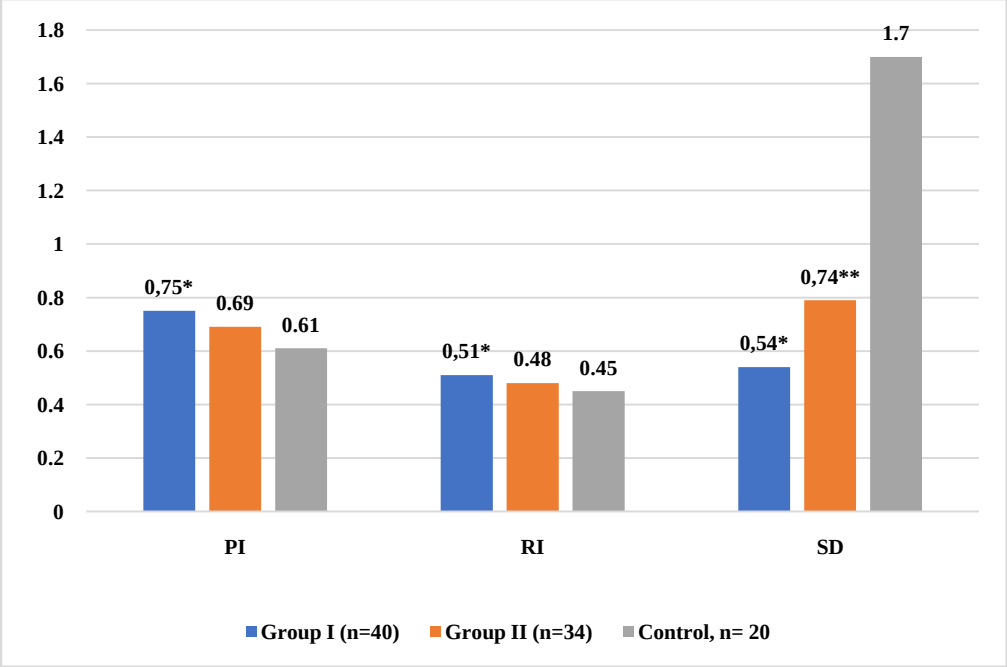


Figure 1. Blood flow parameters after compression of the common carotid artery in healthy subjects and patients with ischemic stroke depending on the presence of a history of TIAs.
Note: ∗ - reliability criterion between group I and control, p<0.05. **- reliability criterion between group II and control, p<0.05.

The results of functional tests also confirm more pronounced disorders in the TIA group, which may indicate a decrease in the adaptive mechanisms of the vascular system. When assessing the blood flow parameters after compression of the CCA in patients of group I, there was no increase in peak and average blood flow velocities, as well as deterioration in the elastic properties of the arteries (PI, SD), an increase in circulatory resistance (diastolic velocity), and the degree of turbulence in the main groups compared to the control group. Changes in these parameters depended on the presence of microvascular complications and show a decrease in the ability of the MCA to change its diameter under the influence of a mechanical factor, which leads to a violation of the ability of the cerebral circulatory system to compensate for hemodynamic deficiency (Fig. 1).
As can be seen from Table 3, the autoregulation index (AI) was significantly lower in Group I, indicating a violation of the brain's ability to maintain stable blood flow. According to the ultrasound duplex scanning of the brachiocephalic vessels, the blood flow velocity in the MCA was significantly more reduced in Group I compared to Group II, indicating insufficient brain perfusion in patients of Group I. As for the vascular reactivity index, it was lower in Group I compared to Group II, reflecting a decrease in the adaptive capabilities of the vascular system (Table 3).

Table 3: Indicators of autoregulation of cerebral circulation

Indicator	Group I (n=40)	Group II (n=34)	p=
Autoregulation index (AI), arb. units	0,63 ± 0,17	0,82 ± 0,14	<0,001*
Blood flow velocity in the MCA (cm/s)	40,05± 5,1	50,7 ± 6,4	<0,001*
Vascular reactivity (%)	15,8 ± 3,3	25,3 ± 4,7	<0,001*

The correlation between autoregulation indices and clinical data was calculated. A negative correlation was found between IA and NIHSS score, which means that a decrease in autoregulation is associated with an increase in the severity of neurological deficit.

Table 4: Correlation between autoregulation indices and clinical data

Parameters	Correlation coefficient (r)	p-value
Autoregulation index and NIHSS score	-0,65	<0,001*
Vascular reactivity and the Rivermead index	0,58	0,002*

A positive correlation was found between vascular reactivity and the Rivermead index, indicating that improved vascular reactivity contributes to increased patient mobility (Table 4).
During the MRI examination, patients in Group I showed larger infarction zones in the carotid basin, as well as

signs of chronic ischemia in zones associated with previous TIAs. In Group II, infarction zones were somewhat less pronounced and more often localized within one anatomical zone.

Thus, the results of this study highlight the importance of taking into account the history of TIAs when assessing hemodynamic changes in patients with ischemic stroke. Decreased blood flow parameters after compression of the common carotid artery in patients with a history of TIAs may indicate the presence of more serious vascular disorders and a predisposition to recurrent strokes. Understanding these mechanisms is key to developing more effective rehabilitation and prevention strategies for vulnerable patient groups.

Patients with previous TIAs have significant impairment of cerebral hemodynamic autoregulation. This may be due to exhaustion of compensatory mechanisms due to repeated episodes of ischemia. A decrease in the autoregulation index and vascular reactivity leads to increased vulnerability of the brain to hemodynamic fluctuations, which increases the risk of recurrent stroke. Impaired autoregulation may contribute to the progression of atherosclerotic changes and plaque destabilization in cerebral arteries. In addition, reduced vascular reactivity limits the brain's ability to adequately respond to changes in systemic arterial pressure, which increases the likelihood of recurrent ischemic events.

The results of this study confirm that the presence of a history of TIAs has a significant impact on the clinical course and extent of damage in the acute period of hemispheric infarction. More pronounced neurological deficit and damage to a larger volume of brain tissue in patients with TIAs emphasize the importance of early diagnosis and preventive measures for this risk group.

Correlation analysis confirmed the association between impaired autoregulation and increased risk of recurrent stroke, highlighting the importance of assessing cerebral hemodynamics in predicting outcomes and planning treatment interventions.

5. CONCLUSIONS

- Impaired autoregulation of cerebral hemodynamics in patients with previous TIAs is a significant risk factor for recurrent stroke.
- A decrease in the autoregulation index and vascular reactivity is associated with an increased degree of disability and worsening functional outcomes.
- Evaluation of the state of autoregulation should be included in the standard examination of patients after stroke for timely identification of risk groups and taking preventive measures.
- Patients with hemispheric infarction in the carotid basin and previous TIAs have a more unfavorable prognosis associated with a greater degree of brain damage and more pronounced neurological deficit. A comprehensive assessment of the clinical picture, neuroimaging and neurophysiological data allows for a better understanding of the nature of the course of the acute period of the disease and the development of more accurate treatment and rehabilitation strategies.

6. Recommendations

- Early diagnostics of autoregulation disorders using TCD and functional tests in patients who have had a stroke.
- Individualized approach to recurrent stroke prevention, including risk factor correction and maintaining optimal systemic arterial pressure.
- Development of rehabilitation programs aimed at restoring cerebral hemodynamics and improving functional outcomes.
- Further research to identify effective strategies for correcting autoregulation disorders and reducing the risk of recurrent stroke.

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