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Neuroimaging Features In Patients With Lacunar Ischemic And Hemorrhagic Stroke

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Abstract: The aim of this study was to investigate the neuroimaging and ultrasound characteristics of cerebral blood flow in patients with lacunar ischemic (LI) and hemorrhagic stroke (HS). A total of 120 patients were examined, including 80 with LI and 40 with HS. MRI/MSCT, color dopplerography, and transcranial dopplerography (TCDG) were used. It was revealed that LI patients were characterized by predominantly atherosclerotic changes with bilateral stenosis of the main cerebral arteries, decreased LBFV, and thickened IMC, even with moderate blood pressure. Patients with HS were more likely to have high blood pressure and vascular deformation without significant stenosis. The findings highlight the diagnostic value of comprehensive neuroimaging and BCA ultrasound for the differential diagnosis and prognosis of cerebrovascular disorders.

Keywords: Lacunar stroke; hemorrhagic stroke; neuroimaging.

Introduction: The relevance of this study is due to the high prevalence and severity of the consequences of acute cerebrovascular accidents, of which both ischemic and hemorrhagic forms occupy a significant place in the structure of neurological diseases and disability in the adult population. Despite significant progress in the diagnosis and treatment of strokes, the problem of timely and accurate neuroimaging remains relevant. This allows not only to confirm the diagnosis but also to assess the nature, location, and extent of focal brain changes, which directly influences the choice of therapeutic strategy and prognosis. Such imaging is particularly important in distinguishing between the subtypes of ischemic (lacunar) and hemorrhagic stroke [1].

For patients with lacunar cerebral infarction and those who have suffered a hemorrhagic stroke, the importance of neuroimaging studies (in particular magnetic resonance imaging and/or multispiral CT) becomes key: neuroimaging allows us to identify microangiopathic changes, lacunar foci, extrafocal lesions and features of the ventricular system that accompany the clinical picture and influence the course of the disease and its outcome [2], [3].

However, comparative neuroimaging studies of patients with lacunar and hemorrhagic stroke—including the location, volume, associated brain changes, and their correlation with the clinical presentation—are underrepresented in the literature. Recent studies have shown differences in small vessel parameters (e.g., lacunae, microbleeds) between ischemic and hemorrhagic strokes, confirming the need for further investigation [1], [4].

In this context, studying the neuroimaging characteristics of patients with lacunar and hemorrhagic stroke is highly relevant. The data obtained may contribute to expanding our understanding of stroke pathophysiology, optimizing differential diagnosis, substantiating personalized treatment approaches, and developing prognostic algorithms. Furthermore, the study's results may facilitate earlier detection of subclinical brain changes and improve the effectiveness of medical care for stroke patients.

Study materials and methods. The study was conducted in the Emergency Neurology Department of the Russian Scientific Center for Emergency Medical Care from 2014 to 2024. To achieve the study's objectives and tasks, 120 patients were examined: 80 with lacunar infarction and 40 with hemorrhagic stroke in the acute phase with a confirmed diagnosis. Patients' ages ranged from 32 to 86 years, with an average age of 59.7 ± 10.87 years. There were 75 men (62.5%) and

45 women (37.5%)—a male-to-male ratio of 1.67:1.

Our study included patients with cerebral ischemia (80 patients, 66.67%) and hemorrhagic stroke (40 patients, 33.33%) in the hyperacute and acute phases. In the LI brain group, there were 51 (63.75%) men and 29 (36.25%) women (ratio 1.76:1), while in the GI group, there were 24 (60%) men and 16 (40%) women (ratio 1.5:1). The age distribution of the examined patients according to the WHO [29] is presented in Table 1.

Table 1

Age groups	LI (n=80)		GI (n=40)		Total (n=120)	
	Abs	%	Abs	%	Abs	%
Young Age (18-44 years)	3	3,75	3	7,50	6	5,00
Middle Age (45-59 years)	32	40,00	19	47,50	51	42,50
Older Age (60-74 years)	31	38,75	14	35,00	45	37,50
Senior Age (75-90 years)	14	17,50	4	10,00	18	15,00
Total:	80	100	40	100	120	100

Patients underwent MRI and/or MSCT of the brain to assess the volume, location, and nature of lesions; color duplex scanning (CDS) and transcranial Doppler sonography (TCDG) to assess blood flow in the brachiocephalic and intracranial vessels; and blood pressure measurement upon admission. The following parameters were assessed: the presence and degree of stenosis, blood flow velocity (BFV), resistance index (RI), and intima-media thickening (IMT).

Statistical analysis: Data are presented as mean ± standard deviation (M±σ). The following methods were used for analysis: Student's t-test and ANOVA for quantitative data; the χ^2-test for qualitative data; and the Pearson correlation coefficient for assessing relationships. Differences were considered statistically significant at $p \leq 0.05$.

Study results. The functional state of the extra- and intracranial circulation was assessed based on the results of CDS and TCDG of the BCA. Regardless of the stroke type and age, the carotid circulation (CC) was the most common localization of cerebral LI: 34 (85%) patients in Group I and 33 (82.5%) in Group II, while LI in the VBB was recorded in 6 (15) and 7 (17.5%) patients, respectively. In Group III, HI localization in the carotid circulation also predominated: 32 (80%) patients versus 8 (20%) patients with localization in the VBB, i.e., without statistically significant intergroup differences. According to TCD and CDS data, atherosclerotic changes in the arteries were most frequently detected in patients with cerebral lichen planus (76 patients (95.0%) (in Group I – 37 (92.5%) patients and in Group II – 39 (97.5%) patients). Of these, hemodynamically significant stenosis was diagnosed in 12 patients (15.79%) with combined lesions (5 (13.51%) and 7 (17.95%), respectively).

Atherosclerotic changes in the vessels affected the cerebral and vegetative vascular walls, i.e., they were diffusely distributed, indicating a systemic impairment of cerebral hemodynamics in cerebral lichen planus.

Table 2.

Incidence of significant ICA stenosis by group

Показатели	1 group (n=40)		2 group (n=40)		3 group (n=40)	
	Abs	%	Abs	%	Abs	%
Unilateral stenosis >50%	6	15,0	7	17,5**	4	10,

						0
Bilateral stenosis>50%	18	45,0 *	16	40,0**	10	25, 0

Note: * - statistically significant (p≤0.05) difference between groups I and III;

- statistically significant (p≤0.05) difference between groups II and III.

In groups I and II, unilateral stenosis of the intracranial ICA greater than 50% was observed more frequently compared to group III. This was characterized by a trend in the ratio between groups I and III (p≥0.05). However, in the ratio between groups II and III, this was statistically significant (p=0.043), as was the case for the ratio of LI to GI (p=0.047) (Table 2). Bilateral massive ICA stenosis greater than 50% during cerebral ischemia was detected in 18 patients (45%) in Group I and 16 patients (40%) in Group II, while in 10 patients (25%) in Group III, with statistically significant differences in both ratios (p=0.039 and p=0.04, respectively) (Table 3).

Table 3

Mean blood pressure values by group (M±σ)

AD (мм.рт.ст.)	1 group (n=40)	2 group (n=40)	3 group (n=40)
Systolic	161,2±11,1*	163,4±10,3**	210,8±14,7
Diastolic	90,7±5,8*	91,5±5,9	105,6±7,4

Note: * - statistically significant (p≤0.05) difference between groups I and III;

** - statistically significant (p≤0.05) difference between groups II and III.

This indicates that cerebral stenosis most frequently developed with massive stenoses of two or more BCC vessels. At the same time, the comparison of the average blood pressure/diameter in groups I and II at hospitalization was statistically significantly (p≤0.05) lower than in group III, despite the lower proportion of stenotic lesions of the BCC vessels.

Thus, cerebral stenosis can develop with massive bilateral stenosis of two or more BCC vessels, even with relatively low blood pressure/diameter values. According to the results of the BCA CDS, in the GI group, a tendency toward decreased resting BFV and RI with slight asymmetry in cerebral hemodynamics was more frequently recorded. Vessel patency remained preserved, but their geometry was altered, often with a non-linear course in the VA. Meanwhile, the intima-media complex (IMC) remained within the normal range of 0.08-0.09 cm.

In patients who have had cerebral vascular accidents, stenosis of the BCA is present. The CCA LBFV was significantly lower on the right side – 36 cm/sec – than on the left (43.8 cm/sec, with normal values ranging from 50-124 cm/sec). In patients with cerebral vascular accidents, the ECA LBFV remained within normal limits on both sides, suggesting less involvement of extracranial vessels in the pathological process. Symmetrical and asymmetrical main blood flow, coupled with impaired perfusion, hyalinosis, and arterial stenosis of perforating arteries, are more frequently observed in small cortical cerebral vascular accidents with rapid improvement in neurological deficit.

Most patients with multiple foci of cerebral vascular accidents showed echographic signs of stenotic arterial stenosis in the CCA and ICA – hyperechoic arterial plaques with stenosis of up to 50-55% of their lumen. Deformations of the ICA and VA were also observed. The IMM thickened to 1.2-2.4 mm (on average 1.86±0.56).

Thus, ultrasound Doppler imaging of the cerebral arteries (MAG) revealed patency, deviations, and deformations in the bilaterial carotid arteries (BCAs) in the overwhelming majority of patients with cerebral infarction, which collectively led to significant cerebral perfusion deficits.

CONCLUSIONS

1. Neuroimaging (MRI/MSCT) showed that lacunar infarctions are most often localized in the carotid circulation (85% and 82.5% in groups I and II,

respectively). A similar localization also predominates in hemorrhagic stroke (80%), confirming the significant role of this area in various types of stroke.

2. Atherosclerotic changes in the cerebral vessels were detected in 95% of patients with cerebral infarction, with hemodynamically significant stenosis diagnosed in 15.79%. Atherosclerosis was diffuse, affecting both the carotid and vertebrobasilar circulations.

3. Bilateral stenosis of greater than 50% in the internal carotid arteries (ICA) was statistically significantly more common in lacunar strokes than in hemorrhagic strokes ($p < 0.05$), indicating a systemic nature of the main artery lesions in this patient group.

4. Mean blood pressure values on admission were significantly higher in patients with hemorrhagic stroke (systolic BP - 210.8 mmHg, diastolic BP - 105.6 mmHg) compared to patients with LI ($p \leq 0.05$), despite less severe stenotic arterial lesions. 5. In cerebral vascular infarction, deformations, decreased linear blood flow velocity (LBFV), and thickening of the intima-media complex (up to 2.4 mm) were detected, indicating combined vascular damage and the development of chronic hypoperfusion.

6. Patients with vascular infarction exhibit echographic signs of stenosing atherosclerosis, including hyperechoic plaques with decreased vascular lumen, particularly in the internal carotid artery and vertebral artery.

7. The obtained results confirm that neuroimaging and ultrasound of the main arteries of the head are essential methods in the differential diagnosis and risk stratification of stroke, enabling the detection of vascular abnormalities even in patients with moderate hypertension.

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