ORIGINAL ARTICLE

CONTENTS

Ultrasonographic changes of carotid vessels in patients in the early recovery period of atherothrombotic stroke

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ABSTRACT

Aim: To study the state of extracranial carotid vessels in patients with atherothrombotic stroke in the early recovery period (ASERP) according to duplex scanning data.

Materials and Methods: 130 patients in ASERP, were studied. 69 men and 61 women. aged (60.42±7.4) years. Duplex scanning of the vessels of the neck was performed on a Siemens Acuson X 300 device with a linear multi-frequency sensor of 4–10 MHz. The classification of stenozoocclusive lesions of vessels was carried out according to the classification of B.V. Gaidar. Atherosclerotic plaques (AP) are divided into 5 types according to the Nicolaides and Gerulaka classification.

Results: Atherosclerotic stenoses were found in all patients of ASERP: (90%),- in 3.4%. AP type 1 was found in 15% of cases; 2 types - in 33.8%; 3 types - in 26%; type 4 accounted for 12.3% and type 5 accounted for 12.3% of cases. APwhich causing moderate stenosis had a high degree of embologenicity due to the hypoechogenicity and heterogeneity of atherosclerotic plaques of types I, II and III. When the level of stenosis increased, tendency to increase the density and hyperechogenicity of the AP was noted.

Conclusions: 89% patients with ASERP had non-critical, hemodynamically insignificant stenoses of the carotid arteries. Types II and III AP, mostly of an eccentric structure, dominated. Moderate stenoses were more often caused by echo-negative atherosclerotic layers, which is a source of increased embologenicity, and stenoses of a greater degree, for the most part, were echo-positive.

KEY WORDS: stroke, atherosclerotic plaque, degree of stenosis, carotid basin

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INTRODUCTION

Detection of atherosclerotic lesions of the carotid arteries and subsequent slowing or stopping of the progression of atherosclerotic plaques with the help of pharmacological effects significantly reduces the risk of recurrent stroke in patients with a history of atherothrombotic stroke [1]. The most affordable, non-invasive method of examining cerebral arteries to detect changes is ultrasound diagnostics (US). The accuracy of this method is confirmed by the high degree of correlation of the measured indicators with the results of the study of the material after carotid endarterectomy. When examining brachiocephalic arteries, the following parameters are evaluated: patency, geometry, diameter, state of the vascular wall (integrity, surface, thickness of the intima-media complex, degree of differentiation into layers); the state of the lumen of vessels: the presence of atherosclerotic layers, their localization, extent, echogenicity and degree of obliteration. For the clinician, the characteristic of atherosclerotic plaque is of particular interest, along with determining the degree of stenosis [1-4].

Image analysis of atherosclerotic plaque identifies three distinct textural patterns: hypoechoic (corresponding to lipid-rich plaques and hemorrhages), iso- or moderately hyperechoic (fibrous or fibrofatty plaques), and hyperechoic with shadowing (calcified plaques). Hypoechoic or dyshomogeneous plaques with neovascularization, surface irregularities have a greater tendency to ulceration, embolization and are more prone to clinical complications than hyperechoic, calcified, homogeneous plaques with a smooth surface and lack of neovascularization [3-6]. However, despite the fact that plaque characteristics and echomorphology help to identify high-risk patients, in current practice, the degree of stenosis remains the main determinant of clinical decisions. Atherosclerosis is considered an etiological factor of stroke if there is confirmatory dopplerographic or angiographic evidence of extracranial or intracranial artery occlusion or stenosis of more than 50% [2, 7].

It should be noted that statin therapy causes biochemical remodeling of atherosclerotic plaque with

a greater effect on lipid components than on total plaque size [3, 8].

Pathological deformations of extracranial carotid arteries occupy a special place among the causes of ischemic disorders of cerebral circulation. According to observations, ICA abnormalities detected on ultrasound occur in 10-43% of the population of patients without atherosclerotic lesions of the ICA, diabetes and hypertension [2, 5]. At the same time, ICA kinking is observed in 5-25% of patients with symptomatic cerebrovascular insufficiency, or in patients with identified stenosis of the internal carotid artery.

AIM

The aim of the study is to study ultrasonographic changes in the extracranial carotid vessels in patients with atherothrombotic stroke in the early recovery period.

MATERIALS AND METHODS

A clinical and laboratory analysis of 130 patients with an atherothrombotic stroke in the early recovery period (ASERP) (from 3 to 6 months after an acute stroke in 2020-2023) was conducted. In this time range, when patients were referred to the Ivano-Frankivsk Regional Clinical Hospital for the purpose of rehabilitation therapy, an ultrasound duplex scan of the vessels of the neck was repeated, the results of the examination were entered into the patient's outpatient card (f. 025/o). All subjects were taking antiplatelet agents, statins, hypotensive and hypoglycemic drugs for the purpose of secondary prevention of stroke when indicated. Carotid endarterectomy was recommended for patients with hemodynamically significant atherosclerotic stenoses. Among the examined were 69 men and 61 women aged (60.42±7.4) years.

Exclusion criteria were: the presence of severe somatic pathology in the stage of decompensation, oncological diseases, patients with an unknown cause of stroke, patients with cardioembolic and lacunar subtypes of strokes.

Ultrasound duplex scanning of the vessels of the neck was performed on a Siemens Acuson X 300 device with a linear multifrequency sensor from 4–10 mHz) according to standard methods. At the same time, the level of damage to extracranial carotid arteries, the degree of stenosis and the hemodynamic significance of atherosclerotic lesions, the morphological structure of atherosclerotic plaque, its surface, and the pathological tortuosity of extracranial arteries were evaluated.

The classification of stenotic-occlusive lesions of cerebral arteries into hemodynamically significant and insignificant was carried out according to the classification of B. V. Gaidar et al. [3]. According to these criteria, stenosis of the main artery of the 1st degree was diagnosed when the vessel narrowed to 40% of the diameter, 2nd degree – 40–60%, 3rd degree – 60–75%, 4th degree – 75–90%, 5th degree – more than 90%, hemodynamically significant considered stenosis IV–V degree [3, 11].

The nature of the atherosclerotic plaque (AP) according to the classification of Nicolaidese and Geroulaka distinguished five types of atherosclerotic plaques: type I: only echonegative echonegative («soft» homogeneous plaque); II type: mostly echonegative with more than 50% hypoechoic areas (heterogeneous hypoechoic plaque); type III: mostly echo-positive with more than 50% hyperechoic areas (heterogeneous hyperechoic plaque); IV type: only echo-positive («dense» homogeneous plaque); V type: pronounced calcinosis, which gives an acoustic shadow.

Statistical processing of the obtained data was carried out using the statistical analysis program IBM SPSS Statistics 26. The frequency of qualitative indicators is presented in absolute (n) and relative (%) frequencies with 95% CI values in the form «n (%; 95% CI)».

The assessment of the reliability of the differences in the obtained results in different groups of observations and the testing of the null hypothesis was carried out by calculating the Pearson's chi-square ($\chi 2$) correspondence criterion.

RESULTS

Atherosclerotic stenoses were found in all patients of ASERP: (<40%), - in 20% of cases, (40-60%), - in 36.9% of cases, (75-90%), - in 7.6% and (>90%), - in 3.4% (Table 1). The localization of the atherosclerotic plaque, which was more than 50%, corresponded to the side of the affected hemisphere. In 27% of cases, a combined lesion of the vessels on both sides of the carotid vessels was noted. At the same time, the side of the affected hemisphere corresponded to the side of atherosclerotic layering with greater stenosis in 20% of cases. In the remaining 7% where hemodynamically insignificant stenoses were ascertained, the side of the affected hemisphere corresponded to the side of localization of the hypoechoic plaque.

The majority of patients (89%) had non-critical, hemodynamically insignificant stenoses of the carotid arteries up to 75%. In these subjects with a clinical picture of ischemic stroke, heterogeneous atherosclerotic plaques were found in the basin of the middle cerebral arteries and the anterior cerebral artery, and different variants of the plaque coating were noted.

Table 1. Level of atherosclerotic stenosis and morphological structure of atherosclerotic plaque according to duplex scan results

Level of stenosis	Type of atherosclerotic plaque															p
	I n=20			II n=44			III n=34			IV n=16			V n=16			
	abs.	P, %	±m	abs.	P, %	±m	abs.	P, %	±m	abs.	P, %	±m	abs.	P, %	±m	
<40% (n=26)	6	30,0	10,25	10	22,7	6,32	6	17,60	6,54	4	25,0	10,83	-			=0,751
40–60 % (n=48)	8	40,0	10,95	19	43,2	7,47	14	41,20	8,44	4	25,00	10,83	3	18,8	9,76	=0,367
60-75% (n=42)	6	30,0	10,25	14	31,8	7,02	13	38,20	8,33	5	31,30	11,59	4	25,0	10,83	=0,913
75-90% (n=10)	-			1	2,3	2,25	1	2,90	2,90	2	12,50	8,27	6*/#	37,5	12,10	<0,001
>90% (n=4)	-			-			-			1	6,30	6,05	3	18,8	9,76	=0,600

Notes:

* - statistically significant difference compared to the indicators of the group of patients with type II atherosclerotic plaque;

- statistically significant difference compared to the indicators of the group of patients with type III atherosclerotic plaque.

Table 2. Ultrasound characteristics of atherosclerotic plaques in patients in the early recovery period of atherothrombotic stroke

Ultrasonic characteristics of AP	Patients with ASERP (n=130)	% (95 % CI)
Atherosclerotic plaques:		
- eccentric	97	74,6(66,2-81,8)
- circular	33	25,4(18,2-33,8)
AP surface:		
- smooth	32	24,6(17,5-32,9)
- unequal	22	16,9(10,9-24,9)
- with decay	10	7,7(3,8-13,7)
- with an ulcer	14	10,8(6,0-17,4)
- combined	52	40,0(31,5-49,0)

Thus, AP type 1 (homogeneous, hypodense or "soft") was found in 15% of cases; 2 types (heterogeneous with a predominant hypodense or "soft" component) - in 33.8%; 3 types (heterogeneous with a predominant hyperdense or "dense" component) - in 26%; type 4 (homogeneous hyperdense or "dense") accounted for 12.3% and type 5 (with pronounced calcinosis, which produces an acoustic shadow) accounted for 12.3% of cases. A statistically significant difference was found between the specific gravity of people with atherosclerotic plaques of type V and the proportion of people with type II ($p<0.001$) and III ($p<0.001$) atherosclerotic plaques. No significant difference was found between the proportions of individuals with IV and V type of atherosclerotic plaques ($p>0.05$).

Atherosclerotic layers causing moderate stenosis (up to 60%) had a high degree of embologenicity due to the heterogeneity of atherosclerotic plaques of types I, II and III. These results prompted the correction of therapy in the form of an increase in the dose of the statin used. With an increase in the level of stenosis of the internal carotid artery, a tendency to calcification of atherosclerotic plaque was observed.

Most of the atherosclerotic layers, 97 (74,6; 95 % CI 66,2-81,8 %) had an eccentric structure of AP, in 33 (25,4; 95% CI 18,2-33,8 %) AP were circular (Table 2).

In 32 (24.6; 95% CI 17,5-32,9 %) patients, the surface of AP was smooth, in 22 (16,9; 95% CI 10,9-24,9 %) - uneven, in 10 (7,7; 95% CI 3,8-13,7 %) - with disintegration, in 14 (10,8; 95% CI 6,0-17,4 %) - with ulcer, in 52 (40,0; 95% CI 31,5-49,0 %) - with a combined surface.

In 17 (13%) patients, ICA tortuosity was detected, of which 11 (64%) were C-shaped, 6 (36%) were S-shaped. 13 (10%) patients had unilateral tortuosity, 4 (3%) had bilateral tortuosity. Deformations with a local increase in blood flow rate twice or more in the bending zone were considered hemodynamically significant. In most cases, ICA deformations were combined with atherosclerotic vessel damage.

DISCUSSION

The degree of stenosis of the carotid vessels has long been used as the main factor for determining the risk of stroke and is an indication for treatment [1, 3]. However, additional characteristics of the plaque, such as the morphology and surface of the plaque, which are often not taken into account by clinicians, play an equally important role in the occurrence of vascular disasters, which explains the term «vulnerable plaque» [4].

According to the results of our study, despite the use of statins for the secondary prevention of atherothrombotic stroke, we found the presence of potentially dangerous unstable atherosclerotic plaques of types I and II in almost half of the examined patients. At the same time, soft, unstable atherosclerotic plaques were noted mainly in patients with hemodynamically insignificant stenoses up to 60%. It follows from this that the risk of recurrent stroke in such patients is also high, as fragments of atherothrombotic layers, breaking off, can at any time create an obstacle to cerebral blood flow. This fact is explained by the insufficient effect of statin therapy on lipid metabolism and remodeling of atherosclerotic plaques and necessitates correction of the applied therapy.

Our findings are similar to the results of the NASCET study, which found that unstable atherosclerotic plaque increased the risk of neurological symptoms approximately fourfold compared with stable plaque. Researchers Simon A, Gariepy J, Chironi G and others. argue that even an increase in the thickness of the wall of the common carotid artery is considered a reflection of arterial inflammation and is a predictor of cerebrovascular events in the short term, and conversely, dense calcified plaques are less often associated with ischemic events and may be a protective feature of plaques, preventing thrombus aggregation or providing additional mechanical stability plaque surfaces. The same data were reported in a systematic review by Kwee RM. Where symptomatic plaques have been shown to have less calcification than asymptomatic plaques.

However, there are other, completely opposite opinions reflected in the meta-analysis (Brinjikji W, Rabinstein AA, Lanzino G, etc.) who claim that the instability of the atherosclerotic plaque detected by ultrasound does not correlate with neurological symptoms and does not pose a danger for the patient.

Given the fact that statins affect mainly the change in the structure of plaques, and not the degree of stenosis, their use in the early stages is logical and necessary. According to the results of a study of prospective ultrasound monitoring of ulcer plaques during the year (Schminke U, Motsch L, Hilker L) it was established that the vast majority of carotid plaques (76.5%) remained unchanged, 23.5% of ulcers regressed, while only 5.8% ulcers progressed. Consistent with these results, another research group followed carotid plaques for 2 years and concluded that 67% of carotid plaques showed no change during follow-up, 6% regressed, and 5% progressed [8].

That is, the understanding of the fact that atherosclerotic plaque can progress and transform from stable to unstable even on the background of statin therapy confirms the need for dynamic duplex scanning of the vessels of the neck in order to detect potentially embolic plaques.

CONCLUSIONS

During duplex scanning of the carotid vessels, it is important to pay attention not only to the degree of stenosis, but also to the echomorphology of the atherosclerotic plaque, since hypoechoic layers that cause even a slight degree of stenosis often provoke clinical complications.

According to the results of our study, 89% of patients with ASERP had non-critical stenoses of the carotid arteries, up to 75% with a clinical picture of ischemic stroke in the basin of the middle and anterior cerebral arteries. The vast majority of atherosclerotic plaques in the examined persons had an eccentric structure 97 (74.6; 95% CI 66.2-81.8) with a combined surface 52 (40.0; 95% CI 31.5-49.0).

In 74 patients (57%), atherosclerotic layers caused stenosis (< 60%) and had a high degree of embologenicity due to the heterogeneity of atherosclerotic plaques of types I, II and III. When the level of stenosis of the internal carotid artery increased, a tendency to calcification of the atherosclerotic plaque was observed, so hemodynamically significant stenoses (75-90%) were caused mainly by echo-positive («dense» hyperechoic) plaques of IV and V types (<0.001).

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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