
ORIGINAL ARTICLE

Morphological Characteristics of Atherosclerotic Plaques of The Carotid Arteries, Clinical Characteristics of Patients with Diabetes Mellitus and Concomitant Diseases

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ABSTRACT

This article is devoted to the morphological study of atherosclerotic plaques of the internal carotid artery, which can be a source of embolism and narrowing of the artery lumen and the development of complications such as ischemic stroke of the brain. The clinical characteristics of patients with diabetes mellitus and concomitant pathologies are also presented in order to increase the effectiveness of anesthesia for carotid endarterectomy.

Keywords: atherosclerosis, carotid sinus, carotid endarterectomy, plaque structure, perfusion pressure, cerebral blood flow

Received 24.09.2024

Revised 10.10.2024

Accepted 12.11.2024

How to cite this article:

Reimnazarova Z J. Morphological Characteristics of Atherosclerotic Plaques of The Carotid Arteries, Clinical Characteristics of Patients with Diabetes Mellitus and Concomitant Diseases. Adv. Biores., Vol 15 (6) November 2024: 177-182.

INTRODUCTION

Despite the development of methods for diagnosing lesions of extracranial vessels, the meticulously described and proven technique of surgical interventions, the number of ischemic cerebral strokes during operations and in the early postoperative period remains high. All this leads to the fact that cerebrovascular diseases retain their medical and social significance as one of the leading problems. Of all the causes of ischemic stroke, extracranial lesions of the internal carotid artery (occlusions, stenosis) reach 60-40% [1, 19]. In recent decades, significant progress has been made in the study of various forms of ischemic cerebrovascular accidents (ICA), one of the leading causes of which is atherosclerosis of the main arteries of the head - the internal carotid arteries (ICA) [2,3,4,5,6,7,8].

Stenosis of the internal carotid artery is the main cause of ischemic stroke. Treatment of this pathology is a key role in the prevention CVA [9]. Carotid endarterectomy has proven its effectiveness in preventing the development of neurological complications [10,11,12].

One of the main directions in the study of the pathogenesis of ICD is the morphological study of the structure of atherosclerotic plaques of the ICA and its comparison with clinical data and the results of clinical and instrumental studies. The purpose of this study is a comparative characteristic of atherosclerotic plaques obtained during carotid endarterectomy in patients with diabetes mellitus, coronary heart disease and other concomitant diseases [13,14,15].

Currently, when deciding on the indications for CE, preoperative ultrasound duplex scanning of the ICA is widely practiced, with the help of which the degree of atherostenosis of the ICA, the echostructure of plaques, and the condition of their cap are determined. Quite a large discrepancy in the results of studies indicates the need for an in-depth study of the structure of ICA plaques and its comparison with duplex scanning data in order to identify the components and processes in plaques that determine their ultrasound properties, as well as the reasons for the discrepancy between the ultrasound characteristics and the structure of plaques [16,17,18].

The purpose of the research is to investigate the morphological characteristics of atherosclerotic plaques in the carotid arteries and analyze how these characteristics correlate with clinical profiles of patients diagnosed with diabetes mellitus and concomitant diseases.

MATERIAL AND METHODS

The study was conducted at the Republican Specialized Surgical Scientific and Practical Medical Center (RSSSPMC named after academician V. Vakhidov) in the anesthesiology department in the period from 2022 to 2024 inclusive. The subject of the study was the optimization of the perioperative period using morphological examination of the atherosclerotic plaque. The study included 25 patients operated on in the kidney transplant and vascular surgery department.

Patients clinical characteristics.

Table1. Patients division by age and gender.

Age	Men		Women		Total	
	abs.	%	abs.	%	abs.	%
18-43 years old	-	-	-	-	-	-
43-59 years old	6	24,0	-	-	6	24,0
60-74 years old	12	48,0	5	20,0	17	68,0
75-85 years old	2	8,0	-	-	2	8,0
Total	20	80,0	5	20,0	25	100,0
Average age, years	64,2±8,62		69,8±2,58		65,32±8,07	

The average age of patients was 65,32±8,07 years.

More than half (80%) of the operated patients were men. Women accounted for 20% (n=5). As for age, patients in the age group of 60–75 years predominated n=17, which amounted to 68%.

Patients' division depending on diagnosis is presented in Table 2.

Table 2: Patients' division by nosology

Indicators	Total, n=25	
	abs.	%
Stenosis of the ICA on the right	8	32
Stenosis of the ICA on the left	4	16
Stenosis of the ICA on both sides	9	36
Critical stenosis of the ICA on the right	1	4
Critical stenosis of the ICA on both sides	3	12

The surgical intervention was performed under general anesthesia (TVA, TVA + inhalation). Among the concomitant pathologies associated with cardiovascular system disorders were: ischemic heart disease occurred in 16 patients (64%), arterial hypertension in 25 patients (100%), obesity of varying degrees was detected in 5 patients (20%), diabetes mellitus in 9 (36%), CVA in 4 (16%), TIA in 2 (8%) and chronic cerebral circulation insufficiency (CCCI) stage III in 20, chronic cerebrovascular accident stage IV in 5 patients.

The physical status of patients before surgery was assessed using the classification of the American Society of Anesthesiologists (ASA) and the patients belonged to class III.

Morphological study of atherosclerotic plaques (ASP)

All patients underwent ECG, echocardiography, ultrasound examination of SA in the preoperative period and histological examination of AS in the postoperative period.

RESULTS AND DISCUSSION

The data of morphological study of atherosclerotic plaques removed from patients with diabetes mellitus and other concomitant diseases were compared. Comparison of plaque structure was performed taking into account the degree of ICA stenosis, which was determined in the preoperative period using ultrasound duplex scanning. Depending on the severity of CA atherosclerosis, 3 groups of atherosclerotic plaques were identified: those blocking the lumen by no more than 1/3, with a smooth surface; with ulceration of the cap, soft consistency and necrosis; rising above the intima with blockage of more than 50% of the lumen and thrombotic overlay on the surface.

After fixation in formalin solution, biopsy specimens were cut into several pieces, macroscopically visible areas of ulceration of the plaque surface, thrombotic masses, hemorrhage in plaques, areas of CS stenosis.

The blocks were embedded in paraffin, 5-8 μm thick sections were stained with hematoxylin and eosin, picrofuchsin according to van Gieson; elastic fibers, lime and fibrin were detected using the Perls reaction. When examining biopsy specimens, their changes associated with surgical manipulations were taken into account: complete or partial absence of endothelium, penetration (imbibition) of blood into the CS wall, ruptures, partial deformation of the atheromatous and calcified contents of the plaque. A detailed macroscopic characteristic of the structure of each plaque was described for the presence of foci of atheromatosis, fibrosis, calcification, necrosis and edema of fibrous structures, lipophages, newly formed vessels, hemorrhage into the plaque, thinning and ulceration of the cap, etc., as well as the quantity (small, moderate, large). At the end of the biopsy examination, a conclusion was drawn in the macro description column about the structure and characteristics of the atherosclerotic plaque.

Microscopic examination of the CA plaques revealed structural components and processes characteristic of severe atherosclerosis. Most plaques contained atheromatous masses with cholesterol crystals among them; in 30% of biopsies, atheromatous masses in the form of one or more foci constituted the main volume of plaques (Fig. 1), while in some biopsies, the surface layers of the plaques were thinned or destroyed. In 7 (28%) plaques, there were small or medium-sized areas of atheromatosis located in their deep sections. In most plaques, lumpy and lamellar calcifications were found, which were mainly small in size and located deep in the plaques. In 8 (32%) plaques, calcification foci occupied at least 1/4 of their volume, while in 4 (16%) of them, calcifications spread into the surface layers of the plaques (Fig. 7). The degree of expression of sclerotic processes in plaques also varied: in 14 (56%) plaques, areas of fibrosis occupied almost the entire area of sections (Fig. 8). In 6 (24%) plaques, fibrosis was expressed insignificantly. In all plaques, foci of hyalinosis were also detected, in some plaques - foci of necrosis (Fig. 4 A) and edema (Fig. 4 B) of fibrous structures. In some plaques, foci of edema occupied a significant part of the area of their cross section, which could probably lead to an increase in the volume of plaques and the degree of stenosis of the ICA. Cellular elements in plaques were mainly represented by lipophages (Fig. 6, A), as well as siderophages, lymphocytes and plasma cells, located mainly perivascularly in the form of small clusters and infiltrates (Fig. 3). In 4 (16%) plaques near atheromatous masses, single giant multinucleated cells with perifocal nuclei arrangement containing cholesterol crystals in the cytoplasm were found. In many plaques, newly formed thin-walled vessels of the capillary and sinusoidal types were found, which were located diffusely or in groups of 3-4 vessels (Fig. 2, G). The cellular elements in the plaques were mainly represented by lipophages (Fig. 2, B), as well as siderophages, lymphocytes and plasma cells, located mainly perivascularly in the form of small clusters and infiltrates. In 59 (30%) plaques near atheromatous masses, giant multinucleated cells of the foreign body giant cell type were found, many of which contained cholesterol crystals in the cytoplasm. In many plaques, newly formed thin-walled vessels of the capillary and sinusoidal types were found, which were located diffusely or in groups of 3-6 vessels (Fig. 2). Most of these vessels were oriented along the long axis of the SA, some of them communicated with its lumen. The same amblyogenic material should include platelet aggregates (Fig. 5) and organizing parietal thrombi found on the surface of 6 (24%) plaques in the area of thinning and ulceration of their cap; in 4 (16%) cases they were located on the unchanged surface of the plaques. Calcification foci in the thrombotic mass in the form of violet incrustation (Fig. 7), as well as stratification and delamination of fibrous structures in plaque 9 (Fig. 8).

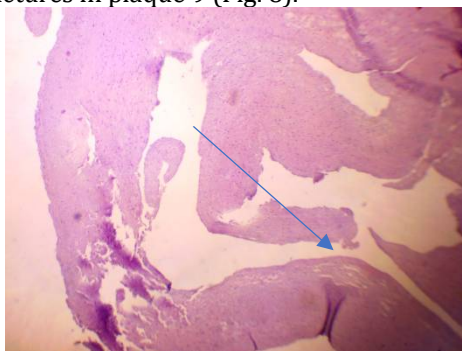


Fig. 1. Focal necrosis of fibrous structures of the plaque (indicated by the arrow) Staining G-E. Zoom: 4x10

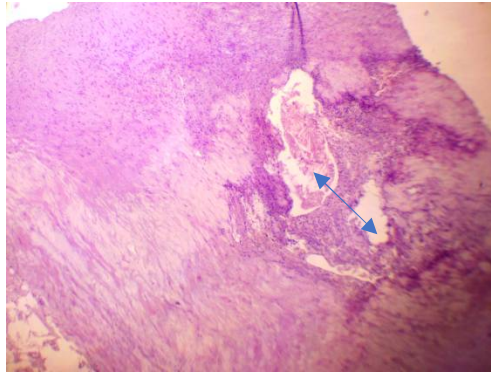


Fig. 2. Newly formed thin-walled vessels of the capillary and sinusoidal types, which were located in groups of 3–4 vessels (marked with an arrow). Staining G-E. Zoom: 4x1

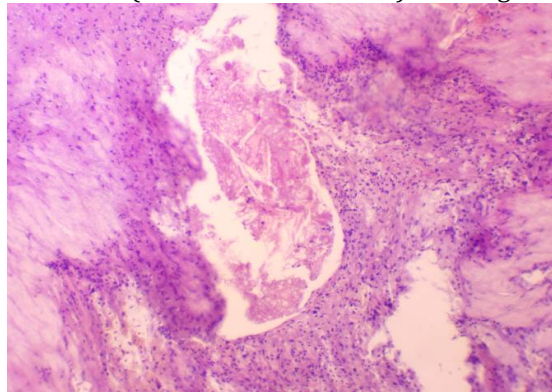


Fig. 3. Lipophages, lymphocytes and plasma cells located mainly perivascularly in the form of small clusters and infiltrates. Staining G-E. Zoom: 4x10.

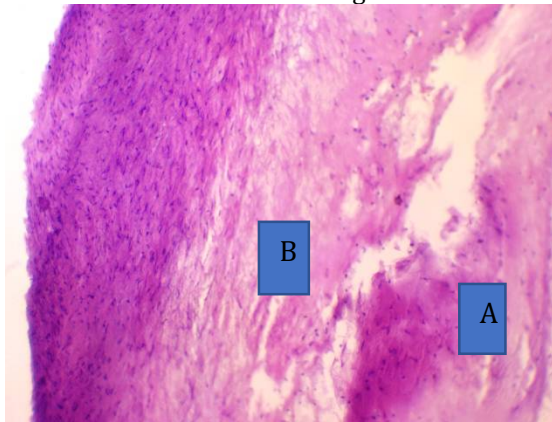


Fig. 4. A - focal necrosis of fibrous structures of the plaque; B - edema of fibrous structures of the plaque. Staining G-E. Zoom: 4x10

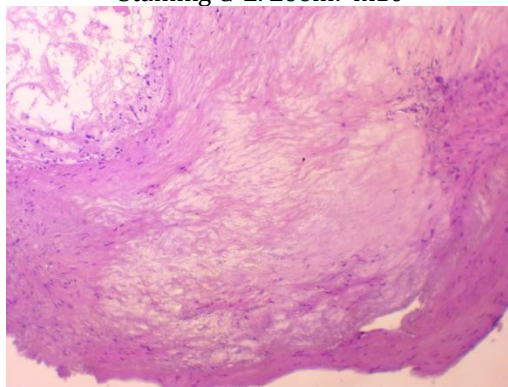


Fig. 5. Platelet aggregates and organizing mural thrombi found on the surface. Stained with G-E. Zoom: 10x10.

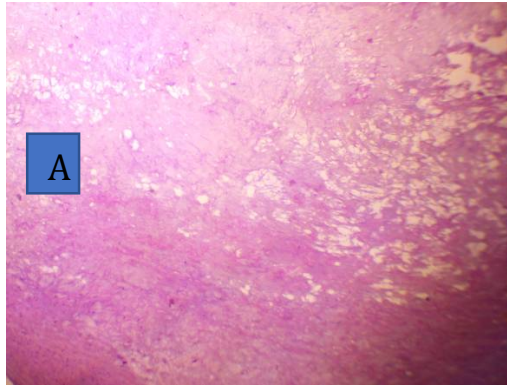


Fig. 6. Platelet and fibrin aggregates in the lower half of the preparation and accumulation of lipophages in the plaque - A. Staining G-E. Zoom: 4x10

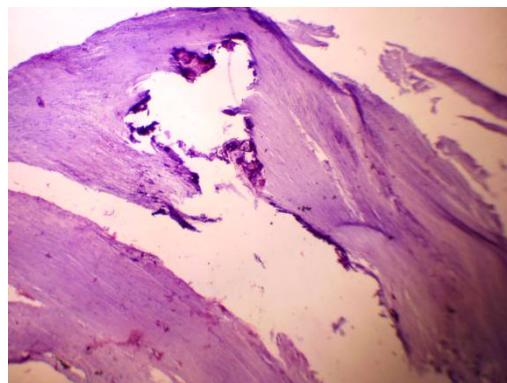


Fig. 7. Calcification foci in the thrombotic mass in the form of encrustation of lumpy purple crystals. Staining G-E. Zoom: 10x10

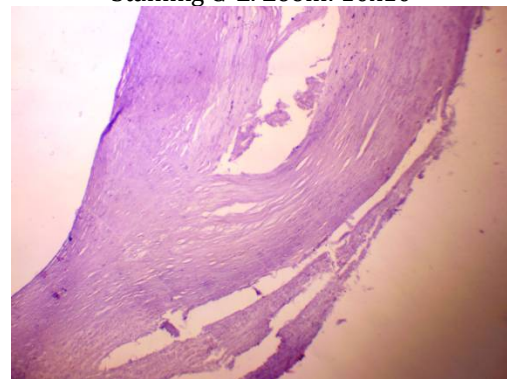


Fig. 8. Edema of fibrous structures of the plaque, stratification and delamination of fibrous structures. Staining G-E. Zoom: 10x10

CONCLUSION

Thus, our study confirms that diabetes may be associated not only with atherosclerosis of the ICA as such, but also to a greater extent with the nature of the course of atherosclerosis, which is confirmed by the morphological structure and composition of the plaque, and the need to take into account when determining the indications for performing CE surgery both in patients with diabetes and other concomitant vascular pathologies in the anamnesis, and in asymptomatic stenosis of the ICA. Morphological examination of 25 atherosclerotic plaques of the internal carotid artery obtained during carotid endarterectomy revealed structural components and processes characteristic of severe atherosclerosis: foci of atheromatosis and edema, necrosis of collagen and elastic fibers, newly formed vessels and hemorrhages of varying age, lipophages and lymphocytes, areas of fibrosis and calcification, as well as thinning and ulceration of the cap, thrombi and plaque contents (atheromatous masses, cholesterol crystals, lipophages, calcifications) on their surface. Clinical and morphological comparisons showed that patients with diabetes mellitus have a history of more severe atherosclerosis of the carotid artery than patients with asymptomatic stenosis. These patients were more often found to have

"unstable" atherosclerotic plaques, characterized by the predominance of atheromatosis foci over fibrosis and petrification areas, thinning and destruction of the cap, layering of blood elements and fibrin with the formation of thrombi on its surface. All this, in turn, is accompanied by a high risk of embolism and the development of ischemic cerebrovascular accident. Also, the presence of such atherosclerotic plaques can lead to mechanical damage and rupture during surgical manipulations in the intraoperative period. It has been established that concomitant arterial hypertension can play a significant role in the pathogenesis of hemorrhages in the atherosclerotic plaque of the internal carotid artery.

Thus, the above results of our study indicate an increase in the effectiveness of anesthesia during carotid endarterectomy in patients with diabetes mellitus and concomitant pathology of the vascular system, which confirms its relevance.

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