



ASSESSMENT OF FORMATION AND CHARACTERIZATION OF ARTERIAL FEMORAL-POPLITEAL SHUNT

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ABSTRACT

Age-related, pathogenic, and traumatic alterations in the major superficial vein following its isolation by an open technique before the creation of an anastomosis were investigated using ultrasound Dopplerography and morphological analysis. It is demonstrated that in multiple observations, the lumen enlarges and the value of the elasticity index moderately declines. Age-related changes in the wall of the great saphenous vein were characterized by coarsening of connective tissue structures in the subendothelial layer of the inner shell, which in places had thickening with the replacement of elastic fibers with collagen. Pathological alterations that were evaluated morphologically included sclerosis, hypertrophy, and, occasionally, indications of atrophy and elastolysis. When a vein is isolated due to its injury, edema, desquamation of the endothelium, and hemorrhages occur in the endothelial layer and subendothelium, which may play a role in future graft stenosis. The analysis of long-term results was carried out based on clinical examination data and ultrasound Dopplerography. The five-year patency of shunts was 64%, and the seven-year patency was 43%.

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Introduction

Despite the significant progress of vascular surgery in the last decade, the treatment of patients with severe lower limb ischemia caused by occlusive lesions of the arteries of the femoral-popliteal-tibial segments remains one of the urgent problems [1]. Autogenous graft transplantation is considered the method of choice in most cases of reconstructive interventions on medium- and small-caliber arteries. Autovena has better patency in the long-term period compared to a prosthesis during infrainguinal reconstructions. In the Republican cancer center of Vladikavkaz (Republic of North Ossetia-Alania, Russia), in the period from 2010 to 2017, 453 patients with lesions of the superficial femoral artery were treated. Among them, some had lesions of the popliteal and tibial arteries. Bilateral occlusions occurred in 145 (32%) individuals. The average age of patients with atherosclerosis was 54 ± 3.5 years. All of them underwent reconstructive surgery on the arteries in most cases with the use of a large saphenous vein, which is the most favorable conduit for femoral-popliteal bypass surgery [2, 3]. The histomorphological properties of this vein are quite variable. Age-related and varicose changes and pathological processes associated with diabetes may occur in the large subcutaneous vein [4-6]. Also, an important role among the causes of dysfunction of venous transplants is played by injury to its wall during the isolation of a vein [7, 8].

Objective: to study age-related, pathological, and traumatic structural changes in the large superficial vein after its isolation by an open method before the formation of anastomosis for monitoring the shunt in the long-term period.

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Materials and Methods

The best method of assessing the condition of the vein is duplex ultrasound, which allows you to determine the size of the vein, anatomical changes, and patency. To determine the condition of the large saphenous vein as a future graft for the affected arterial basin, it was examined using ultrasound Dopplerography. The diameter of the veins and the functional state of the terminal valve apparatus were determined. The data obtained were analyzed, taking into account the duration of the disease. In some patients, the morphological structure of a piece of the implanted vein was studied. The distal section of the vein was studied when it was isolated openly, the preparations were fixed, poured into paraffin, and cross sections were prepared with subsequent staining with hematoxylin and eosin, fuchsylin according to Hart and picrotoxin according to Van Gieson. The nature and severity of age-related and pathological processes in intima, media, and adventitia were determined. Depending on the degree of severity, these changes were described as focal, moderately pronounced, or pronounced. When analyzing the data obtained, the following factors were taken into account: the duration of the disease and the age of the patients.

Results and Discussion

The large subcutaneous vein, being, unlike deep veins, a muscle-type vessel freely located in the subcutaneous tissue, isolated relative to the underlying muscle-fascial space, responds to the changing hemodynamic load largely due to its own tone and elastic properties, which are provided by the normal functioning of the connective tissue and smooth muscle matrix of the vascular wall. The determination, according to ultrasound scanning, of the main anatomical and functional characteristics of the main superficial veins of the lower extremities showed that in several observations, there is a dilation of the lumen and the failure of the terminal valve apparatus already in the early stages of the disease. There was also often a moderate decrease in the value of the elasticity index relative to the maximum values as the duration of the pathology increased. The data obtained may indirectly indicate pathological changes in the wall of the large saphenous vein, which reduce the ability of the musculoelastic framework to regulate the volume of the vein with an increase in transmural pressure [9].

It is known that intercellular edema, desquamation of the endothelium, and hemorrhages occur in the endothelial layer and subendothelium during the isolation of a vein and its preparation for implantation due to even microscopic trauma [10]. We have assessed the level of traumatic impact on the vein wall. In almost a third of patients, we observed erosion of the endothelium with adhesion of shaped blood elements, sometimes tears of the inner shell within the subendothelial layer, and dissection of the vein wall without visible damage (**Figure 1**). Thus, intraoperative manipulations with the vein before its anastomosis can lead to injuries that play a role in future graft stenosis.

In the elderly, the subcutaneous veins of the lower extremities may be varicose. Even if the vein looks normal macroscopically, there may be thickening of the inner and middle membranes, which adversely affects their patency [11]. We have studied age-related and pathological changes in the wall of the large saphenous vein after its extraction for subsequent transplantation. As a result of morphological analysis, all patients included in the study and the age of the patients showed signs of structural restructuring of the vessel. Age-related changes were characterized by the presence of undulating folds of the inner shell. It retained a single-row endothelium with a thin underlying subendothelial layer, in which some coarsening of connective tissue structures was noted. In places, it had thickened with the replacement of elastic fibers with collagen. The middle shell contained circularly arranged bundles of smooth muscle cells without hypertrophy of muscle elements, or there was a slight hypertrophy of circularly arranged smooth muscle cells with coarsening of connective tissue structures (**Figure 2**). There was often a high degree of development of collagen fibers, the appearance of a network of collagen fibers at the border between the inner and middle shells along the entire perimeter of the vessel. The elastic fibers in the middle shell were mostly unchanged; only occasionally, their fragmentation was revealed. Longitudinal bundles of smooth myocytes of normal thickness, in the absence of sclerotic changes, were detected in the outer shell, and sufficiently thick, mostly intact elastic fibers, numerous vasa vasorum, were determined [12].

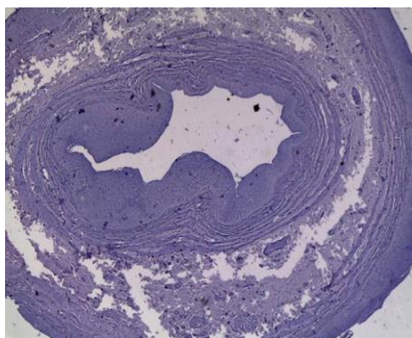


Figure 1. Dissection of the middle shell of the large saphenous vein. Staining with hematoxylin and eosin. Magnification 80:1

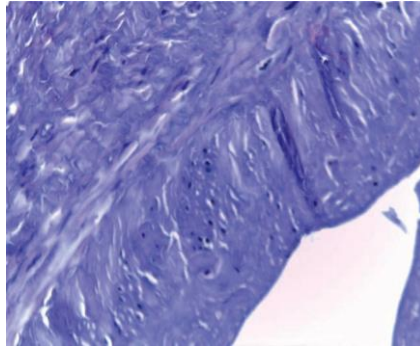


Figure 2. Focal sclerotic changes in the inner lining of the large saphenous vein. Staining with hematoxylin and eosin. Magnification 400:1

Morphological assessment of pathological changes revealed a combination of sclerosis, hypertrophy, and, in some cases, signs of atrophy. The inner shell had an uneven thickness: in some areas, it was thickened due to sclerosis; in others, it was somewhat atrophic. The endothelial layer was not expressed everywhere; sometimes, endotheliocytes were absent for a long time. The subendothelial layer is thickened. In the muscular layer of the intima, collagen fibers of a sufficiently significant thickness were found, often bricking up individual bundles of smooth myocytes. Myocytes looked atrophic. In individual vessels, plaque-like fibrous-elastic protrusions form in the annular thickenings of the intima. Due to the intensive growth of dense connective tissue, the middle shell was stratified, while the myocytes retained their orientation and formed layers. Smooth muscle cells were unevenly hypertrophied and muff-like, surrounded by collagen fibers (**Figure 3**). In adventitia, thickening, sclerosis, and the presence of longitudinal bundles of smooth myocytes of different thicknesses were noted. Significantly pronounced elastolysis was noted. At the same time, in the inner shell, the plexus of these fibers was determined only in certain areas, and their decay took place throughout the rest. The pronounced disintegration of elastic fibers into fragments was determined in the middle and outer shells. In adventitial vessels of both arterial and venous links, with this variant of changes in the vein wall, significant structural transformations were also noted in the form of hypertrophy of muscle layers with fibroelastosis. Thus, the large subcutaneous vein used as an autograft during autogenous femoral-popliteal bypass surgery may have a different degree of initial structural adjustment due to both age-related and pathological changes.

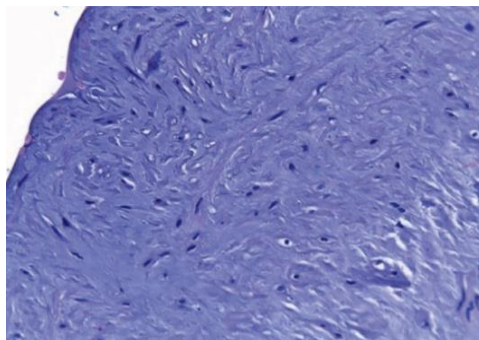


Figure 3. Hypertrophy of myocytes, sclerotic changes in the middle shell of the great saphenous vein. Staining with hematoxylin and eosin. Magnification 400:1

The mechanism and morphology of the lesion of autogenous shunts can be different: various processes can occur in autogenous shunts at different times after surgery: thrombosis and hyperplasia of the intimal layer, atheromatous [13]. Desquamation of the endothelium takes place as soon as arterial blood flow starts to affect the autogenous graft, especially in the anastomosis zone. [14]. Platelets are fixed in this place, and a blood clot is formed. Over the next few days, it matures. Intimal hyperplasia is caused by damage to the intima during bypass surgery. It is characterized by the proliferation and migration of smooth muscle cells from the middle shell to the intima. As the time after surgery increases, so-called "arterialization" of the venous shunt and hyperplasia of its intima occurs. The shunt acquires the adaptive mechanisms necessary for a full-fledged blood flow but becomes susceptible to atherosclerotic damage no less than the native arterial bed [15]. Shortly, there is no atherosclerotic degeneration of venous shunts, and the main reason for their closure is thrombotic occlusion. In the long-term period, on the contrary, mainly atherosclerotic changes in the "arterialized" venous bed can lead to both occlusion and shunt stenosis. The analysis of the immediate results was carried out by us based on the data of clinical examination and ultrasound Dopplerography. Thrombosis developed in 5.8% of patients with atherosclerosis in the first hours after surgery. One of the causes of thrombosis in 32% of people was an embolism of fragments of atheromatous plaques in the distal bed. This can be associated with the detachment or tearing of a fragment of the altered intima due to rough manipulation of the affected femoral arteries as a result of repeated clamping with clamps, an attempt at endarterectomy with the leaving of free fragments of plaques in the lumen, squeezing an atheromatous fragment from the mouth of the collateral during its ligation or clamping,

etc. Early postoperative thrombosis has iatrogenic origins that result from technical and tactical mistakes. Remember that the venous wall is less elastic than the arterial wall, which prevents it from adapting to high blood pressure situations and ensuring optimal blood flow through the shunt. This results in slowed blood flow and increased thrombosis. In 231 (51%) patients, distal anastomosis was formed above the knee joint gap; in other 222 (49%) patients, distal anastomosis was imposed with the popliteal artery below the knee joint gap. When comparing the frequency of early postoperative thrombosis in both groups, it was noted that the frequency of thrombosis in the group of patients who underwent anastomosis above the knee joint gap was lower than in those who underwent distal anastomosis lower (3.9% vs. 5.0%). The analysis of long-term results was carried out based on clinical examination data and ultrasound Dopplerography. The five-year patency of shunts was 64%, and the seven-year patency was 43%.

Conclusion

Ultrasound scanning of the main superficial veins of the lower extremities showed in 30% of patients dilation of the lumen and the failure of the terminal valve apparatus already in the early stages of the disease and a moderate decrease in the elasticity index relative to the maximum values. The subendothelial layer of the inner shell, which in some areas thickened with the replacement of elastic fibres with collagen, was coarsened by age-related alterations in the wall of the great saphenous vein. Morphological assessment of pathological changes revealed a combination of sclerosis, hypertrophy, and, in some cases, signs of atrophy and elastolysis. The inner shell had an uneven thickness: in some areas, it was thickened due to sclerosis. In others, it was somewhat atrophic. The middle shell was stratified, and smooth muscle cells were unevenly hypertrophied and muff-like, surrounded by collagen fibers. When a vein is isolated due to its injury, edema, desquamation of the endothelium, and hemorrhages occur in the endothelial layer and subendothelium, which may play a role in future graft stenosis. The conducted studies can play a certain role in determining the influence of risk factors to improve the results of surgical treatment of patients with lesions of the femoral-popliteal arterial segment in the infrainguinal position.

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Ethics statement: All patients signed an agreement for volunteer participation in the experiment.

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