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ENDOASCULAR TECHNOLOGIES AND RECONSTRUCTIVE INTERVENTIONS ON PROFOUND FEMORAL ARTERY AT REVASCULARIZATION OF MULTILEVEL STENOTIC-OCCLUSIVE PROCESS OF INFRAINGUINAL ARTERIAL CHANNEL

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Abstract

Introduction. Number of patients with obliterating lesions of the aorta and main arteries of the lower extremities has been steadily increasing every year. When choosing the scope of surgical treatment all the features of the multilevel stenotic-occlusive process of the infrainguinal arterial bed should be taken into account.

Purpose. To improve the results of revascularization of the infrainguinal arterial bed by applying surgical intervention on profound femoral artery and endovascular methods to restore permeability of the outflow arteries.

Materials and methods. The work is based on the results of examination and surgical treatment of 264 patients with stenotic-occlusive process of the infrainguinal arterial bed. There were four groups of patients. The basis of revascularization interventions on the infranguinal artery was shunt surgery. Bypass surgery was performed using a reverse autovein. The combined shunt was used for localization of the distal anastomosis at the level of the popliteal, shin arteries, tibioperinel trunk.

Results. In atherosclerotic stenotic-occlusive lesions of the infrainguinal arterial bed of the lower extremity, the volume of surgical treatment depends on the level of the occlusive process, the functional state of the PFA and the blood flow pathways. And the method of surgical intervention in shunt interventions is determined by the type of distal lesion and the level of imposition of distal and proximal anastomoses.

Conclusion. The use of endovascular methods of revascularization and reconstructive interventions on PFA in combination with femoral-distal shunt operations contributes to good and satisfactory results of surgical treatment of stenotic-occlusive processes of the infrainguinal arterial bed.

Key words: arterial stenosis; revascularization; shunting interventions.

Introduction

Number of patients with obliterating lesions of the aorta and main arteries of the lower extremities has been steadily increasing every year [11]. The decisive stage of complex treatment of pathology consists in the implementation of reconstructive intervention [2, 12]. However, generally accepted tactics in the treatment of patients with atherosclerotic stenotic-occlusive process of the infrainguinal arterial bed are not defined [1]. This is due to the multilevel stenotic-occlusive process of the main arterial bed of the lower extremities, the combination of stenotic-occlusive process of different segments of the arterial bed [6], the condition of collateral blood flow, inflow and outflow pathways, [4]. When choosing the

scope of surgical treatment all the features of the multilevel stenotic-occlusive process of the infrainguinal arterial bed should be taken into account.

Purpose. To improve the results of revascularization of the infrainguinal arterial bed by applying surgical intervention on profound femoral artery (PFA) and endovascular methods to restore permeability of the outflow arteries.

Materials and methods. The work is based on the results of examination and surgical treatment of 264 patients with stenotic-occlusive process of the infrainguinal arterial bed. There are four groups of patients. Group 1 - 84 patients with stenotic-occlusive process of the femoral-popliteal segment with satisfactory function of PFA. According to the International Vascular Guidelines for the Treatment of Chronic Ischemia (2019), the clinical stage was determined according to the WIFI classification: 29 (34.52%) patients were diagnosed with the 2nd clinical stage, 38 (45,24%) patients – 3rd clinical stage, 17 (20.24%) patients – 4th clinical stage. Group 2 - 59 patients with stenotic-occlusive process of the femoral-popliteal segment in the conditions of atherosclerotic lesion of PFA. In 14 (23.73%) of them, according to the WIFI classification, 2nd clinical stage was diagnosed, in 25 (44.07%) – 3rd clinical stage, in 19 (32.20%) – 4th clinical stage. Group 3 - 27 patients with segmental stenotic-occlusive process of superficial femoral artery (SFA) and stenotic-occlusive process of fibular artery (FA) in 11 cases. In 3 (11.11%) patients from this group the 2nd clinical stage was diagnosed (30.51%), in 14 (51.85%) – 3rd clinical stage, in 10 (37.03%) – 4th clinical stage. Group 4 - 46 patients with femoral-occlusive process of the femoral/patellar segment, 3 (11.11%) of them had 2nd clinical stage, 19 (70.37%) had 3rd clinical stage, 5 (18.52%) – 4th clinical stage.

All the male patients were 47 - 68 years old (mean age 56.5 ± 4.8 years). Patients with concomitant diabetes were excluded from the study.

The nature of atherosclerotic lesions, the degree of stenotic-occlusive process and the condition of hemodynamics of the arterial bed of the lower extremities were determined using an ultrasonograph "Siemens Acuson S2000". To diagnose occlusive-stenotic lesions of the aorta and main arteries of the lower extremities, angio-enhanced computed tomography was performed using "Philips Brilliance 64".

The basis of revascularization interventions on the infranguinal artery was shunt surgery. Bypass surgery was performed using a reverse autovein. In the absence of suitable for surgery, autovein preference was given to synthetic PTFE prosthetics. The combined shunt - alloprosthesis with an autovenous insert in its distal segment was used for localization of the distal anastomosis at the level of the popliteal, shin arteries, tibioperinel trunk.

Hybrid surgery was performed in 51 patients. Using a one-step method of surgical treatment, before the completion of the first stage in the area of the proximal anastomosis of the femoral-popliteal shunt the introducer was installed. To provide the installation of the introducer we used two methods: in the first one "cuff" was formed out of the venous graft. To do this, the autovein was taken with an excess length of up to 3-4 cm. The proximal anastomosis of the shunt was formed out of the common femoral artery (CFA) in "side to side" type, and in the formed stump of great subcutaneous vein (GSV) the introducer with its subsequent fixing to skin was inserted. In the second method, the installation of the same systems was carried out through a branch of the femoral artery above the proximal anastomosis. Later on, the introducer is inserted on the surface of the skin, followed by its fixation. This method allows to apply endovascular instruments using a synthetic vascular prosthesis. Endovascular angioplasty of the distal arterial bed was performed after suturing the wounds. Check-Flo Performer produced by Cook Incorporated (USA) and Balton (EU), size 4-7 Fr. was used to ensure balloon catheter displacement and easy injection of contrast.

During the endovascular stage the subintimal angioplasty was performed to recanalize the shin arteries. Stenting in this surgical treatment was performed very rarely and only to correct the unsatisfactory results of previous angioplasty. For surgical manipulations we used Armada (Abbot), Amphirion 2 (Medtronic) Cayote (Boston Scientific), Complete SE (Medtronic), Smart (Cordis) and Jaguar (Balton) stents.

At satisfactory revascularization of the shin arterial bed during ultrasonographic examination at the level of the deep arterial arch of the foot, the volumetric blood flow rate was in the range of 2.3-3.4 ml/min or at the level of the superficial arterial arch of the foot, the volumetric blood flow rate was in the range of 4, 8–6.7 ml/min. (Patent for the utility model. Ukraine. № 144327U).

In 28 observations, the distal anastomosis of the femoral-distal shunt was formed in the "end to end" type in the beveled shape at an angle of 45⁰ cylinder. The latter makes it possible to prevent critical stenosis of the anastomosis, which occurs as a result of the healing process and the progression of the atherosclerotic process. (Patent for the utility model. Ukraine. № 117902U).

Results

Group I. In 84 observations, femoral-distal shunts were performed on the background of satisfactory functional condition of PFA. Femoral-popliteal autovenous/alloprosthesis shunting above the knee joint was performed in 15 (17.9%) patients. Deep-popliteal shunting above the knee joint was performed in 8 (9.52%) patients. Femoral-popliteal

autovenous/alloprosthesis shunting lower the knee joint was performed in 31 (36.94%) cases. In 13 of them, femoral-popliteal shunting was supplemented by popliteal-shin autovenous shunting (5 - posterior tibial artery (PTA), 2 - fibular artery (FA), 6 - anterior tibial artery (ATA)). (Table 1). Deepfemoral-knee shunting lower to the knee joint was performed in 18 (21.43%) patients. In 12 (14.29%) patients hybrid surgery was performed - femoral-popliteal autovenous shunting supplemented by subintimal angioplasty of the tibial arteries in 9 cases and stent placement in 3 observations.

Table 1 - Femoral-popliteal shunting

№	The name of the operation	Plastic material	Absolute number	%
1	Femoral-popliteal shunting above the knee joint	Autovein	12	14,29
		Alloprosthesis	3	3,57
2.	Deepfemoral-knee shunting above the knee joint	Autovein	7	8,33
		Alloprosthesis	1	1,19
3.	Femoral-popliteal shunting lower the knee joint	Autovein	23	27,38
		Alloprosthesis	8	9,52
4.	Deepfemoral-knee shunting lower the knee joint	Autovein	14	16,67
		Alloprosthesis	4	4,77
5.	Hybrid femoral-popliteal autovenous shunting + endovascular intervention on the tibial arteries	Autovein	12	14,29
		angioplasty/stenting	9/3	
Total			84	100

Group II. In 59 observations, femoral-distal shunts were performed in stenotic lesions of PFA. Ultrasound duplex scanning in 44 (74.1%) cases revealed stenosis of the first portion of PFA in the range of 53 - 71%, and in 15 (25.4%) cases stenosis at the level of 44 - 56% of the second portion of PFA was revealed. Taking into account the results of the study, in 44 (76.5%) patients femoral-distal shunting (in 9 cases the distal anastomosis was formed to the slit of the knee joint, in 35 - below the slit of the knee joint) was performed simultaneously with profundoplasty.

In 15 patients with stenosis (44 - 56%) of the second portion of PFA in 6 cases surgery included one-stage intraluminal angioplasty of critical stenosis of the SFA and subintimal angioplasty of PFA. And in 9 cases endovascular revascularizing intervention combined subintimal angioplasty of PFA with intraluminal angioplasty of the popliteal artery (PA) (1 observation), tibioperineal trunk (2 cases) and subintimal angioplasty of the tibial arteries (PTA – 2 cases, ATA – 1 case).

Three patients who were diagnosed the stenotic-occlusive process of SFA with spread on inguinal artery (IA) at stenotic lesion of the I portion of PFA, limited to formation of a femoral-tibioperineal autovenous shunt. A similar situation developed as a result of blocking of PFA anastomoses with the descending knee artery, PA and shin arteries by the common occlusive process of SFA, IA and shin arteries. In these circumstances, a decrease in the functionality of PFA was revealed. And when conducting a sonographic study in these conditions at the level of PFA and tibioperineal trunk (TPT) and the peak systolic velocity (PSV) and resistance index (RI) at the level of PFA lower, respectively, than 43.7 ± 6.1 cm/s and $0,58 \pm 0,09$ uo and the indicator of PSV and IR at the level of TPS lower, respectively, then $32,9 \pm 2,8$ cm/s and $0,50 \pm 0,08$ uo there was no need to perform any methods of profundoplasty, only femoral-distal reconstruction was indicated.

Group III. Segmental atherosclerotic process of SFA was diagnosed in 27 patients. In 11 of them with the spread segmental occlusion of the proximal or distal part of SFA we performed prosthetics of the affected segment of the vessel. Reversible GSV was used as a plastic material in 7 observations, 4 people underwent alloprosthesis with PTFE prosthesis ("Gore-Tex" USA). In the stenotic-occlusive process by calcined atherosclerosis (up to 12-15 cm) of the middle third of the SFA we used endovascular methods of revascularization such as subintimal angioplasty in 11 patients and stenting in 5 observations. 7 patients underwent subintimal angioplasty of the tibial arteries.

At spread occlusion of common femoral artery and initial segments of SFA and PFA (3 patients) by calcined atherosclerotic process, after removal of the mentioned segment, alloprosthesis of the affected area with implantation of PFA towards the prosthesis was performed. Alloprosthesis (Gelsoft "VASCUTEK" prosthesis) was used as a plastic material.

When the occlusive calcined atherosclerotic process of CFA was spread to the initial segment (up to 20 cm) of SFA (2 observations), CFA-PFA alloshunting was performed (Gelsoft "VASCUTEK" prosthesis).

Group IV. We performed 36 femoral/patellar-tibial shunts (Table 2). Autovenous prosthetics predominated during shunt surgery. Only in two cases in the absence of autovenous plastic material we used a linear synthetic PTFE prosthesis ("Gore-Tex" USA). In two cases, the distal segment of the autovenous popliteal-PTA shunt was anastomosed with an arteriovenous mouth formed from the PTA and the eponymous vein behind the medial bone (Patent for utility model. Ukraine, № 114546) (Table 2).

Table 2 - Femoral/popliteal-shin shunting surgeries

№	The level of the distal anastomosis	Absolute number of cases	%
1.	Popliteal artery	3	8,33
2.	Tibioperineal trunk	8	22,22
3.	Posterior tibial artery	12	33,33
4.	Fibular artery	5	13,88
5.	Anterior tibial artery	8	22,22
Total		36	

In 8 patients with stenotic-occlusive process of the patellar segment, endovascular angioplasty was performed: subintimal angioplasty in 5 patients and stenting in 3 cases. 2 PTA, 2 FA and 4 ATA were subjected to endovascular revascularization methods.

221 patients underwent surgical treatment. In 51 (23.08%) of them endovascular methods of vascular revascularization were used and in the vast majority these were outflow arteries. In 59 (26.69%) patients, as one of the stages of revascularization of the infrainguinal artery, we performed operation on PFA. In 15 (25.42%) of them endovascular methods of PFA revascularization were used.

In the postoperative period, thrombosis of the reconstruction segment was detected in 5 (2.26%) cases. In two of them, patients with femoral/popliteal-shin shunt, efforts to eliminate the thrombosis of the reconstruction segment were unsuccessful.

In 221 patients the course of the remote postoperative period was traced. Cumulative permeability of the femoral-popliteal segment in patients of group I in 1 and 3 years of the remote postoperative period was 82.1% and 70.2%, respectively. Cumulative permeability of the femoral-popliteal segment in patients of group II in 1 and 3 years after revascularization of the infrainguinal arterial bed was 91.1% and 79.7%, respectively. The cumulative permeability of revascularized segments in patients of group III in 1 and 3 years after surgery was 90.3% and 77.8%, respectively. The cumulative permeability of the femoral/popliteal-shin segment in 1 and 3 years after surgery in group IV was 73.8% and 54.8%, respectively.

Discussion. The volume of surgical treatment depends on the level of the stenotic-occlusive process, the combination of the occlusive process of the arterial segments, functional condition of the PFA and the blood flow pathways. The basis of revascularization interventions on the infrainguinal artery are shunt operations [8]. In the study, shunting surgeries on the infrainguinal bed occupied a dominant position, they were performed in 76.1% of patients. Hybrid surgeries were used in 15.4% of cases. In 11.2% of cases, endovascular revascularization technologies predominated during surgical interventions.

Among shunt surgeries, the most technically difficult are femoral/popliteal-shin shunts [3]. The main difficulties concern the condition of the shin arterial pool, its functional capacity. To overcome them, shunt surgery on the shin arteries and endovascular angioplasty [9] are used. Endovascular angioplasty of the shin arteries is used in hybrid surgery on the arterial bed of the lower extremities [7]. In our study, endovascular interventions on the shin arteries during femoral/popliteal-shin shunting were used in 18.1% of cases.

Deepfemoral-popliteal collateral blood flow is one of the factors that determines the effectiveness of revascularization of the infrainguinal arterial bed [5]. Due to the mentioned above, it is important to reconstruct the deep femoral artery in patients with multilevel lesions of the arteries of the lower extremities. In 59 patients with multi-level stenotic-occlusive process of the infrainguinal arterial bed during ultrasound duplex scanning in 44 (75.8%) cases, stenosis of the mouth (portion I) of PFA was diagnosed, and in 15 (24.2%) cases stenosis was detected at the level of portion II of PFA. In these circumstances, in 44 cases, femoral-distal shunting was accompanied by simultaneous profundoplasty of PFA, and in 15 cases, endovascular intervention on SFA (6 observations) and shin arteries (9 observations) was combined with subintimal angioplasty of the second portion of PFA.

The early postoperative period was complicated in 5 (2.26%) cases by the thrombosis of the reconstruction segment. In two of them (patients with femoral/popliteal-shin stenotic-occlusive process) efforts to eliminate thrombosis of the reconstruction segment were unsuccessful.

Long-term results of revascularizing surgeries on the infrainguinal arterial bed remain unsatisfactory [9]. This is especially noticeable when using endovascular methods of revascularization of the arterial bed of the outflow tract [10]. In our study, the cumulative permeability of the femoral/popliteal-shin segment in 1 and 3 years after surgery was 73.8% and 54.8%, respectively. The best indicators of cumulative permeability in 1 and 3 years after surgery were obtained in patients who underwent hybrid surgery or endovascular revascularization technologies used at all levels of the stenotic-occlusive process of the infrainguinal artery 78.9% and 63.2%, respectively. The combination of shunt surgery with profundoplasty or subintimal angioplasty of PFA contributes to the growth ($p < 0.05$) of the cumulative permeability of revascularized segments, reaching in 1 and 3 years after surgery 91.1% and 79.7%, respectively.

A single tactic in the treatment of patients with atherosclerotic lesions of the main arteries of the lower extremities has not been determined yet. However, the basis of complex treatment of atherosclerotic obliterating diseases of the arterial bed are the reconstructive

operations. In atherosclerotic stenotic-occlusive lesions of the infrainguinal arterial bed of the lower extremity, the volume of surgical treatment depends on the level of the occlusive process, the functional state of the PFA and the blood flow pathways. And the method of surgical intervention in shunt interventions is determined by the type of distal lesion and the level of imposition of distal and proximal anastomoses.

Conclusion. The use of endovascular methods of revascularization and reconstructive interventions on PFA in combination with femoral-distal shunt operations contributes to good and satisfactory results of surgical treatment of stenotic-occlusive processes of the infrainguinal arterial bed.

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