

ENDOVASCULAR ANGIOPLASTY FOR MULTI-LEVEL STENOTIC-OCCLUSIVE LESIONS OF THE FEMORAL-DISTAL ARTERIAL BED IN CASES OF STENOTIC-OCCLUSIVE PROCESS OF THE TIBIAL ARTERIES

I. K. Venher, S. Ya. Kostiv, *B. P. Selskyi, D. V. Khvalyboha,
M. Yu. Orlov, I. V. Faryna, N. I. Tsiupryk

I. HORBACHEVSKY TERNOPIL NATIONAL MEDICAL UNIVERSITY, TERNOPIL, UKRAINE

Background. Occlusive-stenotic lesions of the lower extremity arteries are the second in the structure of cardiovascular diseases, after only coronary heart disease. Surgical treatment of patients with infrainguinal atherosclerotic lesions of the arterial segment is challenging in a number of cases. At the same time, revascularizing surgical interventions on the femoral-distal artery and especially on the tibial arteries in chronic critical ischemia is the only chance to avoid amputation of the lower limb. In this regard, the search and study of optimal methods of revascularizing surgery on the infrainguinal artery for stenotic-occlusive lesions of the arteries of the tibial segment is urgent.

Objective. This study is aimed at promotion of endovascular and hybrid technology in cases of stenotic-occlusive process of the tibial arteries and choosing the optimal surgical treatment tactics in this case.

Methods. Endovascular interventions of the femoral-distal arterial bed in cases of stenotic-occlusive process of the tibial arteries performed for 135 patients at the Department of Vascular and Cardiac Surgery of Ternopil Regional Clinical Hospital have been analysed.

Results. In most cases, endovascular angioplasty of two tibial arteries in hybrid and endovascular methods of revascularization of multilevel atherosclerotic process of the femoral-distal arterial segment of the lower extremity prevents development of thrombosis in tibial segment and allows maintaining the patency of the reconstruction segment and preservation of the lower extremity in 97.57% and 93.44% of cases, respectively.

Conclusions. Endovascular angioplasty of two tibial arteries provides a better result than angioplasty of one isolated tibial artery and allows maintaining the patency of the reconstructed segment for more than 90 percent compare to one isolated angioplasty.

KEYWORDS: vascular surgery; endovascular angioplasty; stenotic-occlusive process; atherosclerosis; revascularization.

Introduction

Occlusive-stenotic lesions of the lower extremity arteries are the second in the structure of cardiovascular diseases, only after coronary heart disease [1]. More than 55% of atherosclerotic lesions of the femoral-distal arterial segments were detected [2]. Occlusive-stenotic lesions of the infrainguinal artery in 35-65% of cases lead to chronic critical ischemia [3]. Surgical treatment of patients with infrainguinal atherosclerotic lesions of the arterial bed is challenging in a number of cases [4]. The complexity of surgical interventions in the femoral-distal arterial area is due to multilevel atherosclerotic lesions of the arterial bed, the

spread of lesions to adjacent arterial basins, collateral arterial basins and the state of outflow pathways – tibial arteries. At the same time, revascularizing surgical interventions on the femoral-distal artery and especially on the tibial arteries in chronic critical ischemia is the only chance to avoid amputation of the lower limb [13]. In this regard, the search and study of optimal methods of revascularizing surgery on the infrainguinal artery for stenotic-occlusive lesions of the tibial arteries is urgent.

Methods

Endovascular angioplasty of the femoral-distal arterial bed in cases of stenotic-occlusive process of the tibial arteries was performed for 135 patients. According to Fontaine's classification, 50 patients were diagnosed with stage

*Corresponding author: Boryslav Selskyi, Assistant Professor,
I. Horbachevsky Ternopil National Medical University, Ternopil,
46000, Ukraine.
E-mail: selskyi_bp@tdmu.edu.ua

IIb of chronic arterial insufficiency (CAI), 63 patients – stage III of CAI, 22 patients – stage IV. The method of hybrid revascularization was applied for 74 patients, and 61 patients underwent endovascular angioplasty of the infrainguinal arterial bed of the lower extremity.

To diagnose occlusive-stenotic lesions of the aorta and main arteries of the lower extremities, computed tomography with angio-amplification was performed by Philips Brilliance CT64 (Philips Medical Systems, the Netherlands) and ultrasound Doppler SonoScape S8 Exp (Italy) for examination of the arterial bed of lower extremities, angiography in the settings of the endovascular X-ray operating room, by angiograph Siemens Axiom Artis (Germany).

Before endovascular surgery double disaggregating therapy was prescribed to all patients were: acetylsalicylic acid drugs one day (160-300 mg/d) and thieperidine drugs (clopidogrel 75 mg/d). One hour before the operation, premedication was prescribed. Promedol 2%, 1.0 ml was most often administered intramuscularly or 30-40 minutes prior intramuscular injection of sol. Relanii or sol. Seduxeni 2.0.

Endovascular interventions were performed under local anaesthesia: 20.0-40.0 ml of 0.5% solution of Novocaine. Before the operation, after access, Heparin solution was administered at a dose of 70-80 U/kg of the patient body weight (5000-7500 U). To prevent arterial spasm of the tibial arteries, it was effective to prescribe Nifedipine 10 mg under the tongue for 15-20 minutes in combination with intravenous administration of 2.0 ml of 2% solution of Papaverine under control of blood pressure.

Check-Flo Performer by Cook Incorporated (USA) and Balton (EU), size 4-7 Fr were used to ensure the change of the balloon catheter and the free introduction of contrast. During the endovascular stage of hybrid surgery, intraluminal angioplasty of the tibial arteries was performed, and in 14 – subintimal angioplasty and subsequent stenting. In all cases, long cylinders (80-150 mm) Armada 35 LL by Abbott Vascular (USA) and Amphirion Deep (Medtronic) Coyote (Boston Scientific), stents CompleteSE (Medtronic), Smart (Cordis) were used.

In all cases, long cylinders (80-150 mm) Armada 35 LL by Abbott Vascular (USA) and Amphirion Deep (Medtronic) Coyote (Boston Scientific), stents CompleteSE (Medtronic), Smart (Cordis) were used.

Retrograde transfemoral access was applied for endovascular manipulations on the

femoral-popliteal-tibial arterial bed. The puncture site of the CFA was placed 2-3 cm below the inguinal fold. Subsequently, endovascular manipulations on the arteries of the femoral-popliteal segment were performed through the 6F introducer. Endovascular angioplasty of the stenotic-occlusive process of the femoral segment was performed with balloon catheters Pan Medical (PEKICO), OPTA PRO (Cordis).

After hybrid and endovascular angioplasty, unfractionated heparin was administered at a dose of 70-80 U/kg of body weight immediately after surgery with continued use until 12-24 hours of the early postoperative period. In 12 to 24 hours, thromboprophylaxis was continued with low molecular weight heparin. Disaggregating therapy with acetylsalicylic acid 100 mg and clopidogrel 75 mg was prescribed.

The criteria for inclusion of patients in the group for surgery was the presence of a multilevel atherosclerotic stenotic-occlusive lesions of the infrainguinal artery. The atherosclerotic process in the tibial arteries was extensive, parietal with segmental stenotic-occlusive lesions of the vascular lumen, the length of which was within 2.8-4.3 cm. Thus, endovascular angioplasty of two tibial arteries was performed to form a functionally suitable outflow pathway in the tibial arteries in cases of stenotic-occlusive process.

Statistical analysis was performed using the statistical software package STATISTICA 6.0 for Windows (StatSoft, Inc. Tulsa OK, USA) and Microsoft Excel (Microsoft office 2013, USA) with data in the form of mean and standard deviation ($M \pm SD$). Spearman correlation analyses were conducted to evaluate correlations between resistance index and type of angioplasty.

Results

Hybrid revascularization of the infrainguinal artery in cases of stenotic-occlusive lesions of the tibial arteries was performed for 74 patients. According to Fontaine's classification of stages of chronic arterial insufficiency, stage IIb of CAI was detected in 26 patients, in 34 patients – stage III; in 14 patients with stage IV of CAI trophic changes on the toes were found.

Atherosclerotic lesions of the arterial bed of the lower extremity was multilevel. It was established that occlusive process in one tibial artery with simultaneous development of stenotic lesions of the other two was detected in 6 (9.83%) cases. The occlusive process of two tibial arteries was established in 59 (79.73%)

cases. In 9 (14.76%) cases, segmental occlusive process was detected simultaneously in all tibial arteries. In 17 (22.97%) cases, atherosclerotic occlusion spread from the level of bifurcation of the common femoral artery (CFA) to the superficial femoral artery; in 38 (51.35%) cases the superficial femoral artery (SFA) was affected; in 7 (9.46%) cases the occlusive process spread from the initial segment of the middle third of the SFA to the level of the first section of the popliteal artery (PA), in 12 (16.22%) – to the II-III section of PA. Ultrasound duplex examination in 17 (22.97%) cases revealed stenosis at the level of 54-68% of the mouth (first section) of the deep femoral artery (DFA).

Hybrid surgery included open reconstruction of the femoral-popliteal segment and endovascular angioplasty of the tibial arteries and was staged one-step. Surgical treatment began with isolation of the femoral and popliteal arteries at typical access sites. In all cases, the distal anastomosis of the autovenous conduit was formed at the level of PA, and in 51 (68.92%) cases it was formed by the end-to-end type from autovein to PA. Subsequently, the autovenous conduit was moved anatomically through the canal along the vascular-nerve bundle to the selected level of the femoral artery. The proximal anastomosis of the autovenous bypass in 17 (22.97%) cases was formed at the level of CFA bifurcation. In these cases, the formation of the proximal anastomosis preceded the profundoplasty. In 57 (77.03%) cases, the proximal anastomosis was formed at the level of SFA: in 38 (66.67%) cases – at the level of the upper third of SFA, in 19 (33.33%) – at the level of the initial section of the middle third of SFA.

Prior to the completion of the first stage of the hybrid operation, a venous stump was formed at the level of the proximal anastomosis of the autovenous conduit to fix the introducer. This was achieved as follows: in the formation of the proximal anastomosis autovein was taken with an excess length of 3-4 cm, the stump was formed from it. An introducer was inserted into it, which was fixed with a tourniquet and was passed through a puncture at a distance of 5-6 cm from the edge of the wound to the skin surface. The venous stump to insert an introducer was used in 65 cases. In 9 cases, the introducer was performed at the level of the proximal anastomosis through the venous branch of the autovenous bypass. Thus, 122 endovascular angioplasties of the tibial arteries were performed: angioplasty of only one of the

tibial arteries was performed in 26 (35.13%) cases, and angioplasty of two vessels simultaneously – in 48 (64.87%) cases.

In 14 patients with stage IV of CAI, trophic changes were found on the toes: in 10 cases superficial trophic changes of the skin of the toes were detected; in 3 cases – deep ulcer of the toes, which involved subcutaneous adipose tissue, tendons and muscles; in one case – a deep ulcer involving subcutaneous adipose tissue, tendons, muscles with bone lesions, 1-3 fingers with spreading to their base. At the end of revascularization on the infrainguinal arterial segment, surgical treatment of trophic changes of the distal segments of the feet was performed in 4 cases. In cases of deep ulcer, which involved subcutaneous adipose tissue, tendons and muscles, exarticulation of the second and third toes was performed, and in one case of deep ulcer involving subcutaneous adipose tissue, tendons, muscles with bone lesions – metatarsal amputation of the distal segment of the foot. So, endovascular revascularization interventions on the infrainguinal artery in stenotic-occlusive lesions of the tibial arteries were performed for 61 patients.

Instrumental examination of a vascular bed of the lower extremity showed multilevel stenotic-occlusive atherosclerotic lesion of the infrainguinal arterial bed. It was established that atherosclerotic lesions of the arteries of the tibial segment were parietal with the spread of the process along the entire length of the artery, which narrowed its lumen and led to segmental occlusion. The length of occluded segments in the tibial arteries was 2.7-3.5 cm. The occlusive process in one vessel was found only in 6 (9.83%) cases with stenotic lesions of the other two tibial arteries. In the vast majority of cases, 42 (68.85%), the occlusive process of two tibial arteries with stenotic lesions of the third of the tibial arteries was revealed. In 9 (14.75%) cases the occlusive process was established simultaneously in all tibial arteries. Tibioperoneal trunk occlusion was revealed in 4 (6.56%) cases.

The results of computed tomography and ultrasound Doppler of the arterial bed of the lower extremities were taken as the basis for the choice of endovascular method of revascularization of the stenotic-occlusive process of the infrainguinal arterial bed of the lower extremity.

After balloon angioplasty, self-opening stents Smart Control (Cordis) were used in 8 cases, Carbostent (Flype) in 6 cases, and Vascu-

lar stent (BARD) in 11 cases. That is, in 40.98% of cases, self-opening stents were used to ensure the effectiveness of endovascular angioplasty of the femoral segment.

The second stage of endovascular intervention on the femoral-popliteal-tibial artery was angioplasty of the tibial arteries. Intraluminal angioplasty of the tibial arteries was performed in 48 cases, and subintimal angioplasty – in 13 cases, followed by stenting. Thus, in total 108 endovascular angioplasties of the tibial arteries were performed: angioplasty of only one of the tibial arteries was performed in 6 (5.56%) cases, and two tibial vessels at the same time – in 51 (83.61%) cases. Endovascular angioplasty of the tibioperineal trunk was performed in 4 cases.

Among 61 patients who underwent endovascular revascularization methods, trophic changes of the toes were revealed in 8 (13.15%) patients with stage IV of CAI; superficial ulcer was found in 5 of them, in 2 cases – a deep ulcer in which subcutaneous adipose tissue, tendons and muscles were involved in the process; and in one case – a deep ulcer involving subcutaneous adipose tissue, tendons, muscles with bone damage. At the end of revascularization manipulations on the infrainguinal arterial bed, surgical treatment of trophic changes of the toes was performed; in 3 cases the toes (2-3 toes) were amputated.

Complications were diagnosed during hybrid revascularization of the infrainguinal artery in cases of stenotic-occlusive lesion of the tibial arteries in 74 patients; 6 of them (8.11%) were diagnosed with complications in the early postoperative period. In 5 (6.76%) cases, thrombosis of the reconstruction segment was revealed, and in one (1.35%) – ineffectiveness of surgery.

After endovascular revascularization of the femoral-distal artery in cases of stenotic-occlusive lesions of the tibial arteries in 61 patients, complications were diagnosed in 5 (8.17%) cases. In 4 (6.56%) cases, thrombosis of the reconstruction segment was revealed and in one (1.64%) – ineffectiveness of surgery.

After hybrid and endovascular revascularization of multilevel atherosclerotic lesions of the femoral-distal arterial bed of the lower extremity thrombosis of the revascularization segment developed in 9 (6.67%) patients: in 8 cases – thrombosis of the popliteal segment, in 1 case – thrombosis of the femoral-popliteal segment.

In 8 patients with thrombosis of the popliteal segment, a minimally invasive thrombec-

tomy method was used [14]: rheological thromboextraction with the Angiojet rheological thromboextraction device (Possies, USA). In two cases rethrombosis of the reconstruction segment developed in the early postoperative period of the minimally invasive method of thrombectomy. Thrombolytic and active conservative therapies were ineffective that led to amputation of the lower extremity.

In 1 case thrombosis of the femoral-popliteal segment developed on the 6th day after two-level endovascular revascularization of atherosclerotic lesions of the femoral-distal arterial segment. In cases of acute arterial insufficiency of the stage IIb, according to Savelyev's classification, open femoral-popliteal autovenous bypass and thrombectomy from the tibial segment were performed. The postoperative period was without complications.

In two (1.48%) cases, both hybrid and endovascular methods of revascularization of the infrainguinal artery were not successful: after surgery, the preservation and progression of lower extremity ischemia was evidenced. Intensive conservative therapy for 7-9 days did not stop development of ischemia that led to amputation of the lower limb.

Discussion

At the moment, there are various opinions regarding the choice of method of revascularization of the infrainguinal arterial bed of the lower extremity: open, endovascular or hybrid [7]. The main purpose of revascularizing surgical interventions is to use the optimal method of revascularization in multilevel atherosclerotic lesions of the femoral-distal arterial bed of the lower extremity and prevent development of a number of postoperative complications [8]. At the same time, many researchers point to development of postoperative complications, including thrombosis of the revascularization segment, the lack of effectiveness of surgery, which are more common when using endovascular revascularization methods [9, 10].

In a number of studies on revascularization of the multilevel stenotic-occlusive process of the femoral-distal arterial bed in cases of stenotic-occlusive lesions of the tibial arteries, endovascular angioplasty of only one tibial artery was used [11, 12]. It is possible that in these circumstances revascularization of only one tibial artery cannot fully perform the tract outflow, which leads to development of thrombosis of the reconstruction segment.

The choice of the extent of surgery was based on the recommendations of the international classification TASC-II (2007) and the European recommendation for the management of patients with the lesions of aortic/iliac-femoral-popliteal arterial bed (2014). According to the European recommendation, the following types were singled out: Type A – single stenosis or single occlusion of the femoral segment up to 10 cm – 38 cases; Type B – multiple lesions of the femoral segment, each of which <5 cm, single lesion <5 cm above the slit of the knee joint, any lesions in the absence of patency of the tibial arteries <5 cm, single stenosis of the popliteal artery – 17 cases; Type C – multiple lesions of the femoral segment with a length of >15 cm, without or with calcification, restenosis or reocclusion after two endovascular interventions – 5 cases; Type D – chronic stenotic-occlusive process of the femoral segment >20 cm with spread to the popliteal artery – 1 case.

The criterion for inclusion in the study was the presence of multilevel atherosclerotic stenotic-occlusive lesion of the infrainguinal artery with underlying stenotic-occlusive lesion of the tibial arteries. Atherosclerotic process in the tibial arteries had extensive, parietal character with segmental stenotic-occlusive lesions of the vascular lumen at the level of 2.8 to 4.3 cm. So, there was a need to form a functionally suitable outflow pathway in the tibial segment. This can be achieved by endovascular angioplasty of the two arteries of the tibia. In the study of the level of blood flow at the level of the popliteal artery the patients underwent endovascular revascularization of multilevel atherosclerotic stenotic-occlusive lesions of femoral-distal arterial bed with endovascular angioplasty of one or two tibial arteries. Resistance index (RI) in the patients with endovascular angioplasty of one tibial artery was at the level of 0.88 ± 0.09 – 0.86 ± 0.10 unit, while RI in patients with endovascular angioplasty of two tibial arteries was 0.67 ± 0.13 unit, which is 1.3 in times lower ($p < 0.05$) than RI in endovascular angioplasty of one tibial artery. The results of the study have proved that endovascular angioplasty of the two tibial arteries produces satisfactory functional conditions of the outflow tract in the tibial segment.

A similar level of incidence of postoperative complications was achieved due to the fact that in revascularization of multilevel atherosclerotic lesions of the femoral-distal arterial bed of the

lower extremity by both hybrid and endovascular methods, mainly endovascular angioplasty of two tibial arteries was performed in 64.87% and 83.61% of cases, respectively. Complications of the early postoperative period developed in those cases when endovascular angioplasty of only one of the tibial arteries was performed during revascularization of the infrainguinal artery.

The analysis of the results of revascularization surgeries during the first month of the early postoperative period has proved that a high clinical level of effectiveness is achieved by hybrid and endovascular methods of revascularization of the stenotic-occlusive process of infrainguinal arterial bed in cases of atherosclerotic lesions of the tibial arteries, endovascular angioplasty of the two tibial arteries in 64.87% and 83.61% of cases, respectively. The preservation of the patency of the reconstruction segment as well as saving the lower extremity was obtained by hybrid methods and endovascular revascularization in 97.57% and 93.44% of cases, respectively.

Conclusions

In most cases, endovascular angioplasty of two tibial arteries in hybrid and endovascular methods of revascularization of multilevel atherosclerotic process of the femoral-distal arterial segment of the lower extremity prevents development of thrombosis in tibial segment and allows maintaining the patency of the reconstruction segment and preservation of the lower extremity in 97.57% and 93.44% of cases, respectively.

Conflict of Interests.

Authors declare no conflict of interests.

Acknowledgments

This paper and the research behind it would not have been possible without the everyday great dedication and hard team work of the Department of Surgery of the Municipal Non-Commercial Enterprise "Ternopil Regional Clinical Hospital" of Ternopil Regional Council.

Author's Contributions. *Ihor Venher, Sviatoslav Kostiv, Boryslav Selskyi* – conceptualization, methodology, formal analysis, writing – original draft, writing – reviewing and editing; *Dymytriy Hvalyboha, Mykola Orlov, Ihor Faryna, Nadiia Tsiupryk* – data curation, writing – reviewing and editing, investigation, formal analysis.

ЕНДОВАСКУЛЯРНА АНГІОПЛАСТИКА ПРИ БАГАТОРІВНЕВОМУ СТЕНОТИЧНО-ОКЛЮЗИВНОМУ ПРОЦЕСІ СТЕГНО-ДИСТАЛЬНОГО АРТЕРІАЛЬНОГО РУСЛА В ПОЄДНАННІ З СТЕНОТИЧНО-ОКЛЮЗИВНИМ ПРОЦЕСОМ ГОМІЛКОВИХ АРТЕРІЙ

І. К. Венгер, С. Я. Костів, Б. П. Сельський, Д. В. Хвалибога,
М. П. Орлов, І. В. Фарина, Н. І. Цюприк

ТЕРНОПІЛЬСЬКИЙ НАЦІОНАЛЬНИЙ МЕДИЧНИЙ УНІВЕРСИТЕТ ІМЕНІ І. Я. ГОРБАЧЕВСЬКОГО МОЗ УКРАЇНИ,
ТЕРНОПІЛЬ, УКРАЇНА

Вступ. У структурі серцево-судинних захворювань стенотично-оклюзійні ураження артерій нижніх кінцівок посідають друге місце, поступаючи лише ішемічній хворобі серця. Хірургічне лікування хворих з атеросклеротичним ураженням інфраінгвінального артеріального сегмента у ряді випадків є складним завданням. У той же час ревазуляризуючі оперативні втручання на стегново-дистальному артеріальному руслі, особливо на гомілкових артеріях при хронічній критичній ішемії залишаються єдиним шансом уникнути ампутації нижньої кінцівки. У зв'язку з цим пошук і апробація оптимальних методів ревазуляризуючого хірургічного втручання на гомілкових артеріях спрямовані на ліквідацію стенотично-оклюзивного ураження артерій гомілки.

Мета. Це дослідження спрямоване на популяризацію ендовазулярних та гібридних хірургічних втручань при стенозно-оклюзійному процесі гомілкових артерій та вибір оптимальної тактики та об'єму лікування в цьому випадку.

Методи. Проведено та проаналізовано результати 135 пацієнтів яким були проведені ендовазулярні втручання на стегно-дистальному руслі в умовах стенотично-оклюзивного процесу гомілкових артерій на базі відділенні серцево-судинної хірургії Комунального некомерційного підприємства «Тернопільська обласна клінічна лікарня» Тернопільської обласної ради.

Результати. У більшості випадків проведення ендовазулярної ангіопластики двох гомілкових артерій при гібридних та ендовазулярних методах ревазуляризації багаторівневих атеросклеротичних уражень стегно-дистального сегменту нижньої кінцівки, запобігає розвитку тромбозу гомілкового сегмента та дозволяє підтримувати прохідність сегменту реконструкції та збереження нижньої кінцівки у 97,57% та 93,44% випадків відповідно.

Висновки. Проведення ендовазулярної ангіопластики двох гомілкових артерій дає достовірно кращий результат, ніж ангіопластика однієї ізольованої гомілкової артерії і дає можливість зберегти прохідність сегменту реконструкції більше ніж на 90 відсотків при порівнянні з однією ізольованою ангіопластикою.

КЛЮЧОВІ СЛОВА: судинна хірургія; ендовазулярна ангіопластика; стенотично-оклюзивний процес; атеросклероз; ревазуляризація.

Information about the authors

Ihor K. Venher, Professor of the Department of Surgery No. 2, I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine.

<https://orcid.org/0000-0003-0170-1995>, e-mail: vengerik@tdmu.edu.ua

Sviatoslav Ya. Kostiv, Professor of the Department of Surgery No. 2, I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine.

<https://orcid.org/0000-0002-7963-5425>, e-mail: kostivsj@tdmu.edu.ua

Boryslav P. Selskyi, Assistant Professor of the Department of Surgery No. 2, I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine.

<https://orcid.org/0000-0001-6787-4843>, e-mail: selskyi_bp@tdmu.edu.ua

Dymytriy V. Hvalyboha, Assistant Professor of the Department of Surgery No. 2, I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine.

<https://orcid.org/0000-0003-0168-0848>, e-mail: hvalyboha@tdmu.edu.ua

Mykola Yu. Orlov, PhD Student of the Department of Surgery No. 2, I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine.

<https://orcid.org/0000-0002-3400-5243>, e-mail: orlov_mypa@tdmu.edu.ua

Ihor V. Faryna, PhD Student of the Department of Surgery No. 2, I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine.

<https://orcid.org/0000-0002-1767-9721>, e-mail: faryna_ivol@tdmu.edu.ua

Nadiia I. Tsiupryk, PhD Student of the Department of Surgery No. 2, I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine.

<https://orcid.org/0000-0002-3989-1563>, e-mail: tsyupryk_cnad@tdmu.edu.ua

References

1. Rollins K, Jackson D, Coughlin P. Meta-Analysis of Contemporary Short- and Long-Term Mortality Rates in Patients Diagnosed With Critical Leg Ischemia. *Journal of Vascular Surgery*. 2014;59:9. <https://doi.org/10.1016/j.jvs.2013.11.010>
2. Neville R, Lidsky M, Capone A, Babrowicz J, Rahbar R, Sidawy A. An Expanded Series of Distal Bypass Using the Distal Vein Patch Technique to Improve Prosthetic Graft Performance in Critical Limb Ischemia. *European Journal of Vascular and Endovascular Surgery*. 2012;44:177-2. <https://doi.org/10.1016/j.ejvs.2012.04.014>
3. Raju R, Mathur K, Ayyappan M, Vijayakumar J, Venkatesan V, Venkatachalapathy B. Composite sequential bypass using profunda vein hitchhike. *Journal of Vascular Surgery*. 2016;64:526-9. <https://doi.org/10.1016/j.jvs.2016.04.050>
4. Nolan B, De Martino R, Stone D, Schanzer A, Goodney P, Walsh D, Cronenwett J. Prior failed ipsilateral percutaneous endovascular intervention in patients with critical limb ischemia predicts poor outcome after lower extremity bypass. *Journal of Vascular Surgery* 2011;54:730-6. <https://doi.org/10.1016/j.jvs.2011.03.236>
5. Maurel B, Lancelvee J, Jacobi D, Bleuet F, Martinez R, Lermusiaux P. Endovascular Treatment of External Iliac Artery Stenoses for Claudication with Systematic Stenting. *Annals of Vascular Surgery*. 2009;23:722-8. <https://doi.org/10.1016/j.avsg.2008.05.019>
6. Nakayama M, Sakamoto F. Proximal direct endarterectomy combined with simultaneous distal endovascular therapy for chronic full-length occlusion of the superficial femoral artery in elderly patients. *Asian Journal of Surgery*. 2013;136:104-10. <https://doi.org/10.1016/j.asjsur.2012.11.006>
7. Menard M, Farber A. The BEST-CLI trial: a multidisciplinary effort to assess whether surgical or endovascular therapy is better for patients with critical limb ischemia. *Seminars in Vascular Surgery*. 2014;27:82-4. <https://doi.org/10.1053/j.semvascsurg.2015.01.003>
8. Motaganahalli R, Menard M, Koopman M, Farber A. BEST Endovascular Versus Best Surgical Therapy in Patients with Critical Limb Ischemia (BEST-CLI) Trial. *Vascular and Endovascular Review*. 2020. <https://doi.org/10.15420/ver.2019.12>
9. Hicks C, Najafian A, Farber A, Menard M, Malas M, Black J, Abularrage C. Below-knee endovascular interventions have better outcomes compared to open bypass for patients with critical limb ischemia. *Vascular Medicine*. 2016;22:28-4. <https://doi.org/10.1177/1358863x16676901>
10. Gentile F, Lundberg G, Hultgren R. Outcome for Endovascular and Open Procedures in Infra-popliteal Lesions for Critical Limb Ischemia: Registry Based Single Center Study. *European Journal of Vascular and Endovascular Surgery*. 2016;52:643-9. <https://doi.org/10.1016/j.ejvs.2016.07.013>
11. Tan H, Zhang L, Guo Q, Yao Y, Sun S, Wang T, Li Y, Xiong K. "One-Stop Hybrid Procedure" in the Treatment of Vascular Injury of Lower Extremity. *Indian Journal of Surgery*. 2013;77:75-8. <https://doi.org/10.1007/s12262-013-0897-1>
12. Borgia F, Di Serafino L, Sannino A et al. AngioJet® rheolytic thrombectomy for acute superficial femoral artery stent or femoropopliteal by-pass thrombosis. *Monaldi Archives for Chest Disease*. 2015. <https://doi.org/10.4081/monaldi.2010.271>
13. Kobza I, Yarema Y, Zhuk R, Fedoriv D. Reconstructive operations on pedal arteries in the treatment of critical limb ischemia. *UMJ Heart & Vessels*. 2018;1:37-9. [In Ukrainian] <https://doi.org/10.30978/hv2018137>

Received 04 April 2022; revised 31 May 2022;
accepted 15 June 2022.

This is open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.