

Hybrid approach of arterial allograft application in reconstructive surgery of the great arteries

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Abstract

The article presents a case of a hybrid intervention using an arterial allograft on the great arteries of the lower extremities in a patient with chronic limb threatening ischemia and prosthetic infection. The patient has a history of repeated operations using synthetic polytetrafluoroethylene and dacron prostheses. In the early postoperative period, a clinical presentation of the prosthesis bed suppuration developed. The article shows the main phases of patient treatment: removal of synthetic prostheses, transplantation of the donor femoral artery, and balloon angioplasty of the popliteal and anterolateral arteries. In the postoperative period, blood circulation in the lower limb is fully compensated, and the dorsal pedis artery pulse is determined. Wounds were healed by primary intention. At the control visit after 6 months, no adverse events were revealed; according to the data of duplex scanning, the main blood flow in the arteries of the leg was recorded, the blood circulation was fully compensated. Thus, hybrid intervention using arterial allograft and balloon angioplasty of the popliteal and anterolateral tibial arteries proved to be an effective method of treatment in the current clinical situation.

Keywords: arterial allograft, prosthesis infection, hybrid procedures.

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Peripheral artery diseases represent a major global health problem. In 2010, about 220 million patients with peripheral arterial diseases were registered globally [1]. Among these cases, chronic limb threatening ischemia (CLTI) cases comprise 1%–2% of the affected individuals [2]. The frequency of amputations in the group of CLTI patients is about 20%, and the frequency of lethal outcomes in the subsequent year is 25%. The so-called “gold standard” of the conduit during bypass surgery is the autovein [3]. In various clinical situations, especially in the case of CLTI and in the absence of an autovein, prosthetic, and native vascular infection, the choice of a graft to save a limb is urgent [4]. Considering prosthetic infection, it should be noted that its frequency after surgeries on the arteries of the lower extremities is up to 6%, whereas the mortality rate is 17% [5]. The frequency of amputations in prosthetic infections is about 40% [6].

The main “classical” method of treating prosthetic infection is graft resection with the complete removal of the infected prosthesis and

extra-anatomical bypass surgery; however, this type of surgery has low efficiency in preserving the limb and, as a rule, represents a “link” to secondary revascularization [7]. One of the promising methods of treating prosthetic infection is the use of allografts, especially in the absence of an autovein [8]. Past studies have indicated high efficiency rates of the use of allografts in prosthetic and native vascular infections, a low rate of complications (3%–6%), persistent eradication of the infection (97%), and high postoperative patency (97% primary patency after 5 years) [9–13].

In recent years, the hybrid surgical method has been increasingly used in about 15% of all revascularizations in the main arteries of the lower extremities [14]. Many authors have noted the high efficiency of hybrid surgeries. For example, Matsagkas revealed that the primary and secondary patency rates in patients after two years were 93.2% and 95.5%, respectively [15]. In this study, a combination of angioplasty and endarterectomy from the common femoral artery was described as a hybrid intervention.

Apparently, there is no “gold standard” in the treatment of critical ischemia. Rather, the combination of techniques used according to indications improves the treatment results, thus reducing the risk of complications. In non-standard clinical situations, such as CLTI with multilevel lesions of the vascular bed combined with prosthetic infection, hybrid interventions have now become the method of choice for saving a limb. In relation to this, we thus present a clinical case of a hybrid intervention with the use of an arterial allograft in a CLTI patient with prosthetic infection.

Clinical case. Patient N (born in 1955) was admitted to the Department of Vascular Surgery of the Regional Clinical Hospital of Ryazan on April 10, 2020 for emergency indications with a diagnosis of atherosclerosis, bilateral femoropopliteal occlusive disease, suppuration of the synthetic femoral-popliteal prosthesis bed, stage IV of the disease on the right (according to the classification of Pokrovsky). The patient also had femoropopliteal repeated bypass surgery with a synthetic prosthesis above the knee joint cleft to the right on 03/15/2020 and a condition after femoropopliteal bypass surgery with a synthetic prosthesis above the knee joint cleft to the right on 07/12/2018. Concomitant diseases included cerebrovascular disease (condition after acute cerebrovascular accident from 2011), moderate right-sided hemiparesis, and degree III hypertension, stage 2, risk 4.

Upon admission, he complained of diastasis of the wound in the lower third of the right thigh, indicating the presence of purulent discharge from the postoperative wound. The above complaints are noted for about two weeks. On examination, the sensitivity and movement in the toes of the right foot were in full volume, and the pulse in the popliteal artery was detected. Diastasis of the postoperative wound was 6 cm×2 cm. Dry necrosis of the distal phalanx of the toe 1 of the right foot was observed. The postoperative wound in the upper third of the thigh healed by primary intention.

The patient was additionally examined. Inoculation for flora (postoperative wound in the lower third of the thigh) from 04/10/2020 revealed *Staphylococcus aureus* 10⁶, sensitive to a wide range of antibiotics (ceftriaxone, gentamycin, etc.). The general clinical and biochemical tests showed no significant deviations, blood glucose was 5.7 mmol/L, body mass index was 24 kg/m², and blood culture was sterile.

The medical history revealed that on 07/12/2018, the patient underwent femoropopliteal bypass surgery above the knee joint cleft on the right with a synthetic prosthesis Ecoflon d = 8 mm (polytetrafluorethylene). Then, on 03/15/2020, repeated femo-



Fig. 1. Angiographic examination of the arteries of the right lower extremity. Critical popliteal artery stenosis.

ropopliteal bypass surgery was performed with a synthetic prosthesis InterGard d = 8 mm (dacron) above the knee joint cleft on the right due to the development of shunt thrombosis. The saphenous veins had a loose type of structure; according to duplex scanning, the maximum diameter of the great saphenous veins was up to 2 mm.

An angiographic study of the arteries of the right lower extremity was performed, in which a critical stenosis of the popliteal artery was revealed (Fig. 1).

In this clinical case, the patient's saphenous veins, as a possible material for reconstructive surgery, had a loose type of structure. According to duplex scanning data, the maximum diameter of the great saphenous veins was up to 2 mm; thus, they were considered unsuitable for bypass surgery. Furthermore, owing to the presence of suppuration in the area of surgical intervention, loose type of structure of the great veins, and critical stenosis of the popliteal artery on the right, it was decided that a hybrid intervention should be performed using an allograft from a postmortal donor as a graft.

On April 12, 2020, a multivisceral harvesting was performed, and a femoral artery allograft was removed from a postmortal donor in compliance with all the rules and norms of transplantation [8]. This meant that the organs and tissues were only harvested from the donor when the death of the brain was pronounced. The femoral artery was conditioned in a solution for cultivation of cell structures RPMI (Roswell Park Memorial Institute) with the addition of gentamicin and fluconazole at a temperature of +4°C. For long-term storage of the grafts, a solution of RPMI 1640 with glutamine supplemented with gentamicin (400 µg/mL) and fluconazole (20 µg/mL) was used [8]. Immediately before transplantation, the graft was prepared in the operating room for use as a material for reconstruction (back table).

The “back table” is the stage of preparation of the donor graft for transplantation, which is performed as a separate surgical intervention on the

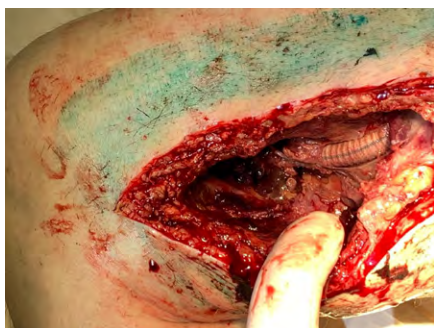


Fig. 2. Anastomosis of the prosthesis and the popliteal artery.

graft. In the operating room, a sterile table is prepared directly next to the patient. The second team of surgeons (in parallel with the main team) prepares the allograft for transplantation; in this way, the lateral branches are tied or sutured and the tightness is checked, after which it is transferred to the main team of surgeons [8].

04/14/2020 (12:00–15:35). The hybrid surgery involved femoral artery transplantation with repeated femoropopliteal bypass surgery above the knee joint cleft with arterial allograft on the right. This was accompanied by X-ray endovascular dilatation of the popliteal and anterior tibial arteries on the right.

Surgery course. Under peridural anesthesia, an incision was made in the lower third of the right thigh along the Ken's line with the excision of the old postoperative wound, and the distal segment of the popliteal artery was isolated along the anastomosis of the synthetic prosthesis and the popliteal artery (Fig. 2). The tourniquets were used. The paraprosthesis hematoma (250 mL) was removed.

The wound was washed with a solution consisting of nitrofuril (furacilin, 200 mL) and hydrogen peroxide (hydrogen peroxide, 100 mL). Anastomosis of the prosthesis (dacron) and the common femoral artery, anastomosis of the prosthesis (polytetrafluorethylene), and bifurcation of the common femoral artery were isolated by an incision in the upper third of the right thigh with the excision of the old scar. The synthetic prostheses were removed. The wounds were repeatedly washed with nitrofuril (furacilin, 200 mL) and hydrogen peroxide (hydrogen peroxide, 100 mL) solutions. A site for anastomosis of the graft and the common femoral artery was prepared. End-to-end anastomosis was formed with a 5/0 prolene suture.

Arterial allograft was pulled subfascially into the incision of the lower third of the thigh. An end-to-end anastomosis of the graft and the popliteal artery was formed using a 6/0 prolene suture. Then, the endovascular stage was performed. The allograft was punctured in the wound of the up-



Fig. 3. X-ray endovascular dilatation of the popliteal artery.



Fig. 4. Angiographic control. Arterial lumen has been restored.

per third of the thigh, after which Introducer 6F (INT6F) was installed. Then, X-ray endovascular dilatation of the popliteal artery (Fig. 3) and the anterior tibial artery was performed along with angiographic control (Fig. 4).

Then, the introducer was removed, and the allograft puncture site was sutured with 6/0 prolene suture. Drains were installed in the postoperative wounds, which were sutured layer-by-layer. The pulse was recorded on the dorsal artery of the foot on the table. The postoperative management protocol was in accordance with the Russian national guidelines for the management of patients with diseases of the arteries of the lower extremities. The sutures were removed on day 12, and by then, the wounds were already healed by primary intention.

The patient was placed under medical supervision and was examined after six months. The blood circulation in the right lower limb was compensated, and a distinct pulse was detected on the artery of the dorsum of the foot. The necrosis of toe I was healed. In addition, the main blood flow in the leg arteries was recorded according to the duplex scanning data.

Discussion. In this clinical situation, hybrid intervention with the use of an arterial allograft had the most optimal rationalization. Here, several alternative methods can be proposed, although these can have disadvantages and limiting characteristics for the conditions of a given clinical case. This is an extra-anatomical bypass surgery with a synthetic prosthesis, which would not have much success due to the multilevel lesion. Furthermore, this procedure involved a graft resection and repeated bypass surgery with a synthetic graft after antibacterial treatment. However, this technique does not guarantee good and stable long-term results in case of prosthetic vascular infection [16].

The patient's great saphenous veins were considered unsuitable materials for reconstruction due to their small diameter. The patient's superficial femoral vein could be used as a conduit for repeated bypass surgery. This technique has good long-term patency and resistance to reinfection [16]. However, it also has its disadvantages; specifically, the sampling of the superficial femoral vein is technically quite traumatic, an increase in the duration of surgery is inevitable, the superficial femoral vein is not always intact or postphlebitically unchanged, and the team must have sufficient experience.

According to the literature, the combination of endovascular and open vascular surgery in the treatment of prosthesis infection in CLTI patients is especially successful in multilevel lesions [17]. The mutual potentiation of the results of both methods has been reported [18].

In our opinion, the most advantageous method in restoring the main blood flow in this clinical situation is a hybrid approach with the preparation of outflow tracts and direct repeated prosthetic repair under conditions of paraprosthetic infection using alloartery.

On the basis of the meta-analysis conducted by Antonopoulos et al. involving 1377 cases, the implantation of an arterial allograft for prosthetic infection can be considered the method of choice. Complications after surgery, which are associated with the use of cryopreserved allograft, such as anastomosis rupture, allograft degeneration, and pseudoaneurysm formation, accounted for up to 6%. To date, 14 studies have reported a reinfection rate of 3% [11].

Despite these circumstances, the place of allografts in reconstructive surgery has yet to be fully determined, and according to the law on transplantation of human organs, tissues or both, the only acceptable option is the possibility of using this only if other medical means cannot guarantee the survival of the patient (recipient) or the restoration of his/her health [9]. The lack of clear

indications and contraindications as well as information on the optimal timing and methods of conservation remain significant limiting factors of the widespread use of allografts in the daily practice of a vascular surgeon, even with access to the technology of vascular harvesting, conservation, and transplantation [8]. Undoubtedly, these issues require further study and fundamental analysis from the standpoint of evidence-based medicine.

Conclusion. A hybrid approach combined with the use of an allograft in the reconstructive surgery of the great arteries in a CLTI patient with prosthetic infection can be an effective method in the absence of a suitable autovein and in a situation wherein it is impossible to use a synthetic prosthesis.

Author contributions. R.E.K. developed the concept and design of the study, analyzed the data obtained, and edited the text; I.A.S. developed the study design and analyzed the data obtained; V.V.K. collected the clinical material, performed diagnostic studies, surgical treatment, and analyzed the data obtained; N.A.S. processed the materials, wrote the text, and reviewed the literature; A.S.P. collected the materials, performed diagnostic studies, and wrote the text; A.A.E. processed the materials, performed surgical treatment, and reviewed the literature.

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REFERENCES

1. Fowkes F.G., Rudan D., Rudan I. et al. Comparison of global estimates of prevalence and risk factors for peripheral artery disease in 2000 and 2010: a systematic review and analysis. *Lancet*. 2013; 382: 1329–1340. DOI: 10.1016/S0140-6736(13)61249-0.
2. Pokrovskij A.V., Jakhontov D.I. Role of venous cuff in femoral-tibial bypass surgery. *Vestnik Natsional'nogo mediko-khirurgicheskogo tsentra im. N.I. Pirogova*. 2013; 8 (4): 18–24. (In Russ.)
3. Bradbury A.W., Adam D.J., Bell J. et al. Bypass versus angioplasty in severe ischaemia of the leg (BASIL) trial: Analysis of amputation free and overall survival by treatment received. *J. Vasc. Surg.* 2010; 51 (Suppl. S): 18–31. DOI: 10.1016/j.jvs.2010.01.074.
4. Kalinin R.E., Solanik N.A., Suchkov I.A. et al. The place of arterial allograft in reconstructive surgery of the main arteries of the lower extremities. *Pirogov Russian Journal of Surgery*. 2020; (9): 69–74. (In Russ.) DOI: 10.17116/hirurgia202009169.
5. Wilson W.R., Bower T.C., Creager M.A. et al. Vascular graft infections, mycotic aneurysms, and endovascular infections: A scientific statement from the American Heart Association. *Circulation*. 2016; 134 (20): e412–e460. DOI: 10.1161/CIR.0000000000000457.
6. Warner M., Nelson R., Lim C. *Vascular graft infection*. Oxford Textbook of Vascular Surgery. 2016; 116. DOI: 10.1016/j.jdc.2018.06.003.

7. Gharamti A., Kanafani Z.A. Vascular graft infections: An update. *Infect. Dis. Clin. North Am.* 2018; 32 (4): 789–809. DOI: 10.1016/j.idc.2018.06.003.
8. Kalinin R.E., Suchkov I.A., Karpov V.V. et al. The first experience of using allografts in surgery of main arteries of lower limbs. *Russian Sklifosovsky journal of Emergency medical care.* 2020; 9 (3): 442–448. (In Russ.) DOI: 10.23934/2223-9022-2020-9-3-442-448.
9. Law of the Russian Federation of December 22, 1992 No. 4180-I “On transplantation of human organs and (or) tissues” (as amended). <http://ivo.garant.ru/#/document/136366/paragraph/92:0> (access date: 03.12.2020). (In Russ.)]
10. Kieffer E., Gomes D., Chiche L. et al. Allograft replacement for infrarenal aortic graft infection: early and late results in 179 patients. *J. Vasc. Surg.* 2004; 39 (5): 1009–1017. DOI: 10.1016/j.jvs.2003.12.040.
11. Koskas F., Goeau-Brissonniere O., Nicolas M.H. et al. Arteries from human beings are less infectible by *Staphylococcus aureus* than polytetrafluoroethylene in an aortic dog model. *J. Vasc. Surg.* 1996; 23 (3): 472–476. DOI: 10.1016/S0741-5214(96)80013-9.
12. Antonopoulos N., Papakonstantinou A., Hardy D., Lyden S. Editor’s choice — cryopreserved allografts for arterial reconstruction after aorto-iliac infection: A systematic review and meta-analysis. *J. Vasc. Surg.* 2019; 58 (1): 120–128. DOI: 10.1016/j.jvs.2019.03.003.
13. Vogt P.R., Brunner-La Rocca H.P., Carrel T. et al. Cryopreserved arterial allografts in the treatment of major vascular infection: a comparison with conventional surgical techniques. *J. Thorac. Cardiovasc. Surg.* 1998; 116: 965–972. DOI: 10.1016/S0022-5223(98)70048-0.
14. Dosluoglu H.H., Lall P., Cherr G.S. et al. Role of simple and complex hybrid revascularization procedures for symptomatic lower extremity occlusive disease. *J. Vasc. Surg.* 2010; 51 (6): 1425–1435.e1. DOI: 10.1016/j.jvs.2010.01.092.
15. Matsagkas M., Kouvelos G., Arnaoutoglou E. et al. Hybrid procedures for patients with critical limb ischemia and severe common femoral artery atherosclerosis. *An. Vasc. Surg.* 2011; 25 (8): 1063–1069. DOI: 10.1016/j.avsg.2011.07.010.
16. Simons C.D., Ali A.T., Foteh K. et al. Unilateral in-line replacement of infected aortofemoral graft infection with femoral vein. *J. Vasc. Surg.* 2017; 65 (4): 1121–1129. DOI: 10.1016/j.jvs.2016.09.051.
17. Troitskiy A.V., Bechtev A.G., Gabasov R.I. et al. Hybrid surgery of multilevel atherosclerotic lesions of aorto-iliac and femoral-popliteal segments. *Diagnosticheskaya i interventzionnaya radiologiya.* 2012; 6 (4): 67–77. (In Russ.)
18. Karpenko A.A., Ignatenko P.V., Beliaev A.M. Hybrid *in situ* replacement for Samson group V *Staphylococcus aureus* aortic graft infection. *BMJ Case Rep.* 2013; 2013: bcr2013010289. DOI: 10.1136/bcr-2013-010289.