Review

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Revascularization in Lesion of Arteries of the Aortoiliac Arterial Segment. Literature Review and Clinical Examples

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ABSTRACT This article reports the main issues concerning the tactics of choosing the treatment of patients with occlusive-stenotic lesions of the aortoiliac segment. The key issues of the current Russian, European and American recommendations for revascularization of the peripheral vessels are demonstrated. Attention is paid to the latest studies comparing the results of open surgery and endovascular correction methods. Clinical cases are presented that demonstrate the optimal results of the use of endovascular technologies in conditions of extensive hemodynamically significant lesions and occlusion of the iliac arteries. The conclusion was made about the high efficiency and safety of interventional management in the treatment of patients with atherosclerotic lesions of the aortoiliac segment.

Keywords: occlusion of the iliac artery, occlusion of the external iliac artery, aorto-iliac segment, recommendations, recanalization, balloon angioplasty, stenting, aorto-femoral prosthetics, aorto-femoral bypass grafting

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BAFS — bifurcation aortofemoral shunting
FPS — femoropopliteal segment
CFA — common femoral artery
CIA — common iliac artery
EIA — external iliac artery
CDS — color duplex scanning
EVC — endovascular correction
ASA — American Society of Anesthesiologists
SVS — Society of Vascular Surgeons
UBE — one-piece bifurcation endografts

The increase in life expectancy of people in the 20th century (population aging) has led to an increase in the pathology provoked by atherosclerosis. Simultaneous deterioration in the quality of life (unhealthy diet, sedentary lifestyle, smoking, etc.) exacerbated this trend [1–3].

Atherosclerosis affects the arteries of large and medium caliber, without affecting the venous bed. However, the venous vessels used in bypass operations are atherosclerotic even to a greater extent than the true arteries [4, 5]. This means that increased pressure and accelerated blood flow in the arteries are the initial factors leading to damage to the endothelium and triggering the process of atherogenesis. В наибольшей степени из-за турбулентности кровотока страдают места разветвлений в артериях и потому являются излюбленной локализацией атеросклеротической бляшки. It is also noteworthy that arteries with low blood flow, such as the internal thoracic and deep femoral arteries, are rarely affected by atherosclerosis, being, so to speak, reserve arteries [6, 7]. In conditions of arterial hypertension, the hemodynamic stress of the endothelium is much more significant than the state of a healthy organism. In addition, arterial hypertension, as well as smoking, causing spasm of the artery, provoke the rupture of an atherosclerotic plaque, followed by thrombosis of the vessel and necrosis of the corresponding organ or tissue [8]. Bypass operations (in particular, bifurcation aortofemoral shunting (BAFS)), developed in the 60s of the last century, made it possible, if not to prevent, then at least to delay adverse cardiovascular outcomes [9]. Simple in execution, they provide additional blood flow to the ischemic organ, without canceling the residual blood flow through the damaged vessel and sparing the compensatory collateral circulation developed by the body over the years [10]. Thanks to these properties, the BAFS operation has become the gold standard in the treatment of occlusions of the aortoiliac segment, having remained practically unchanged since its invention. [11–13].

Later, with the advent of new technological possibilities, an easier solution to the problem was proposed - recanalization of the affected arteries through endovascular balloon angioplasty and stenting [14–17]. The indisputable advantage of the new technique was its low invasiveness and, therefore, acceptability for patients with a high surgical risk (elderly, with concomitant diseases) [18].

Attempts to standardize the indications for X-ray endovascular interventions led to the creation of the Transatlantic International Consensus, in which "... the most detailed classification of the types of lesions of the arteries of the aortoiliac segment, as well as indications and contraindications for endovascular interventions — Inter-Society Consensus for the Management of Peripheral Arterial Disease 2007 (TASC II)» [19]. “Type A” reflects those lesions that respond best to endovascular treatment. In “type B”, the results of endovascular treatment are considered to be good, and therefore such interventions are preferable, while open reconstruction is indicated for other lesions in this zone. The long-term results of operations for type "C" lesions are better than the results of endovascular interventions, so the latter can only be used in high-risk patients. The outcomes of endovascular correction of “type D” lesion do not allow its use as a primary treatment” [19].

The latest, more generalized, recommendations of the European Society of Cardiology and the European Society of Vascular Surgeons (ESC/ESVS) for the diagnosis and treatment of peripheral arterial disease in 2017 suggest revascularization of the aortoiliac segment as follows [20]. For short (less than 5 cm) isolated lesions of the iliac arteries, endovascular therapy is recommended (Class I Level of Evidence C). This is justified by the high long-term patency of more than 90% within 5 years and the low risk of complications [21]. In case of combined lesions of the iliac arteries and infrarenal aorta, both open and endovascular revascularization options are recommended (class IIa level of evidence B). At the same time, data are provided on one- and two-year primary patency after endovascular correction (EVC), which is 87% and 82%, respectively [22]. In young

patients with low operative risk, aortofemoral bifurcation shunting is preferred, and in elderly patients with high operative risk and comorbidities, endovascular intervention is preferred. Endovascular therapy can be considered as a first-line strategy for aortoiliac occlusive lesions if it is performed by an experienced team of specialists and does not compromise subsequent surgical interventions [23–25].

A similar tactic is reflected in the National guidelines for the diagnosis and treatment of diseases of the arteries of the lower extremities of cardiovascular surgeons in Russia of the Russian Society of Angiologists and Vascular Surgeons, the Russian Society of Surgeons and the Russian Cardiology Society "Russian Association of Endocrinologists" 2019 [26]. The low level of evidence for recommendations (B and C) is noteworthy. This is due to the fact that studies of the results of surgical treatment of patients with lesions of the aortoiliac segment are mostly small and non-randomized. More information is required on this topic to be able to draw more unambiguous conclusions.

In practice, according to the world literature, there is also a diversity of opinions on the surgical tactics used. Despite this, certain fundamental points are recognized by most vascular surgeons. Thus, TASC II type A/III injuries are treated endovascularly [27, 28]. Initial therapy for TASC II type C lesions is also endovascular [27, 29]. For patients with complex lesions (TASC II type D), BAFS is the procedure of choice, showing the best long-term results [30, 31].

Primary patency with BAFS reaches 96.7% in 2 years compared to 80% with EVC [32]. That is, the need for re-intervention after EVC reaches 20% [32, 33].

Analysis of a Japanese database over 2 years showed the frequency of restenoses after EVC 11.4%. At the same time, it turned out to be much higher in patients with concomitant lesions of the femoropopliteal segment (FPS) compared with those who had a small diameter stent (less than 8 mm). So in patients with these risk factors, restenoses occurred in 27.1% of cases, while in their absence - only in 5.5% [33].

According to other authors, primary patency with EVC was 88%, 70% and 70%, and secondary - 98%, 87% and 77% for 1, 3 and 5 years, respectively [34, 35].

The relatively low patency rates after BAFS reported in some reports (primary 90.1% and 82.6% at 1 and 3 years) are quite logical, given that currently only severe injuries undergo open surgery, and milder ones treated with endovascular methods [36].

According to some data, there are more technical complications with BAFS than with EVC (14.8% and 4%, respectively) [37], according to others, on the contrary (11.1% with EVC and 3.3% with BAFS). These are bleeding (0.8%), infection of the prosthesis (1%), thrombosis of the prosthesis (0.8%), pseudoaneurysm of the anastomosis, damage to the ureter, inguinal complications (5.3%) [38].

However, after BAFS, there is also a high incidence of systemic complications: from 40 to 8.5% compared with 6.7% (and 3.6% according to other data) after EVC [38]. Among them: myocardial infarction (3.4%), pulmonary embolism, pneumonia, acute respiratory failure (2.6%), acute renal failure (2.6%), stroke, intestinal ischemia, spinal cord ischemia, sexual dysfunction, distal embolization (2.5%) [38].

Mortality in BAFS (2–2.9%) also exceeds that in EVC (1.8–0%) [38, 39]. Moreover, in case of need for repeated surgical intervention for complications of BAFS, it reaches 25% [40]. Thus, according to the results of the analysis of data from more than 400 patients who underwent BAFS over the recent 10 years, it turned out that 30-day mortality was 5%, annual - 11%, 5-year - almost 30%, complications were observed in 42% of patients (in 4% - cardiovascular ones), almost 20% needed a second operation (in 6% - limb amputation, in 7% - incisional hernia, in 5% - infected wound) [41].

Therefore, patients at high surgical risk (with serious heart disease, recent myocardial infarction or stroke, end-stage chronic renal failure, multiple previous abdominal surgeries, retroperitoneal fibrosis, and horseshoe kidney) are recommended EVC [42]. At the same time, various scales have been proposed to assess operational risk, such as ASA (American Society of Anesthesiologists), SVS (Society of Vascular Surgeons), mFI-5 (takes into account concomitant diseases, general functional state of the body). The EVC option for complex lesions of the aortoiliac segment was not proposed by the 2007 TASC II recommendations, but is already allowed in the 2017 ESC/EOSH recommendations [43].

Also important is the fact of a shorter stay of the patient in the hospital (on average from 3 to 6 days) and in the intensive care unit (ICU) (0 days) after EVC compared with BAFS (from 7.76 to 9.9 days in the hospital and from 1.7 to 3.81 days in the ICU) [43]. Accordingly, the cost of hospitalization with EVC ($9,281) is much lower than with BAFS ($23,038) with a comparable cost of the procedures themselves ($2,316 and $1,173). Therefore, EVC is more economical procedure [43].

In TASC II type C/D lesions, as a rule, balloon-expandable or self-expanding stents with or without coating are placed, endoluminally or subintimally; in case of bifurcation injuries, according to the “kissing”technique [44, 45].

There are no differences in systemic morbidity and mortality between bare-metal and coated stents [46]. The primary patency of bare-metal stents is less than that of covered stents (52.6 and 68.7% over 10 years), and the frequency of restenosis is correspondingly higher (17.4 and 11.5% over 5 years; 29.4 and 25.9% over 10 years) [46]. According to other sources, the restenosis rate of bare-metal stents is 5.6% in the 1st year, 11.9% in the 2nd year, and 26.5% in the 3rd year. Covered stents show the best results in the case of moderate to severe calcification of the iliac vessels. Small caliber covered stents less than 8 mm also outperform other stents in primary patency.

In stent grafts, the primary and secondary patency for 1 year is 92.3% and 100%, for 3 years — 83.9% and 100%, for 5 years — 83.9% and 100%, respectively. According to other authors, it reaches values of 96.8% primary and 96.8% secondary patency in 2 years. In still others, the 5-year primary stent-graft patency was 84.1%, while in the case of BAFS in the same center, the patency was at the level of 88.3% [47]. Mortality from these interventions is the same as for BAFS – 2.6%.

Optimal results have been reported with VIABAHN (3-year primary patency of 94.9%) and Advanta stent grafts [48]. At the same time, implantation of the E-Luminnex stent was often (in 48% of cases) accompanied by restenoses. [49].

Primary and secondary patency of covered stents is at the level of 100% and 100%, respectively, for 1 year, 90.6% and 95.7% respectively over 3 years [50].

In 2009, in order to overcome some of the anatomical and physiological shortcomings of “kissing” stents, the technique of covered endovascular reconstruction of the aortic bifurcation (CERAB) was introduced [51, 52]. It is characterized by a more favorable geometry and better blood flow conditions compared to "kissing" stents. The short-term results of CERAB are approaching those of BAFS. CERAB can also be used in combination with chimney-graft to preserve the lateral branches of the aorta [52].

In aortoiliac occlusions, one-piece bifurcation endografts (UBE) are also placed, which have several advantages in terms of protecting the aortic bifurcation and preventing branch antagonism in the distal aorta. UBE protects against potentially fatal aortoiliac rupture in highly calcified lesions and permits possible future endovascular interventions [52–56].

In a certain category of patients, the optimal solution is aortoiliac endarterectomy. These are, firstly, patients with eccentric plaque morphology or small vessel caliber, who are more at risk of vessel rupture or distal embolization in EVC. Secondly, patients with local lesions of the aortic bifurcation [57, 58].

Thus, the task of the surgeon is to choose the most suitable for a particular patient from the whole range of proposed interventions for aortoiliac occlusive lesions in order to achieve the best result with minimal losses. However, the main trend in the choice of revascularization strategy is directed towards EVC, which is justified by the facts presented above.

Next, we present two clinical examples demonstrating the efficacy and safety of EVC in elderly patients with a pronounced comorbid background and a high risk of complications after open surgery.

Clinical example 1.

Patient A., male, 65 years old. Five years ago, pain syndrome developed in the right calf muscle when walking at a distance of up to 500 meters. Subsequently, the "pain-free distance" was reduced to 100 meters. During additional examination, according to color duplex scanning (CDS), occlusion of the common iliac (CIA) and external iliac (EIA) arteries on the right is determined. Due to the presence of a pronounced comorbid background (repeated ischemic strokes in history, myocardial infarction in history, myocardial revascularization in history, diffuse atherosclerotic lesions of the coronary arteries, subcompensated type II diabetes mellitus), a multidisciplinary team (cardiovascular surgeon, endovascular surgeon, cardiologist, anesthesiologist-resuscitator , endocrinologist) made a decision to implement endovascular correction of the identified lesion. The patient was hospitalized at the National Medical Research Center named after V.A. Almazov for recanalization of EIA and CIA with stenting.

Operation progress. After processing the surgical field under local anesthesia with 10.0 ml of 0.25% lidocaine solution, a puncture of the left common femoral artery (CFA) was performed. Contralateral introducer was installed. Angiography was performed: occlusion of the right EIA, CIA (Fig. 1A). Then recanalization of the CIA, EIA was performed. Balloon angioplasty of EIA, CIA was performed using a balloon catheter PTA Admiral

XtremeTM 70x80 mm of firm Medtronic. A stent was placed and implanted in the affected area of the CIA, the upper third of the CFA Boston Scientific 8x120 mm. A stent was inserted and implanted into the affected area of the middle third and lower third of the EIA Boston Scientific 10x30 mm (Fig. 1B). Postdilatation performed with a balloon catheter Medtronic Admiral Xtreme PTA 70x80 mm. Control angiography: no hemodynamically significant stenoses, no dissections or streaks of the contrast agent were found, the main blood flow was restored according to the EIA, CIA, the optimal angiographic result. The sheath from the left EFA is removed on a self-suturing system AngioSeal VIP.

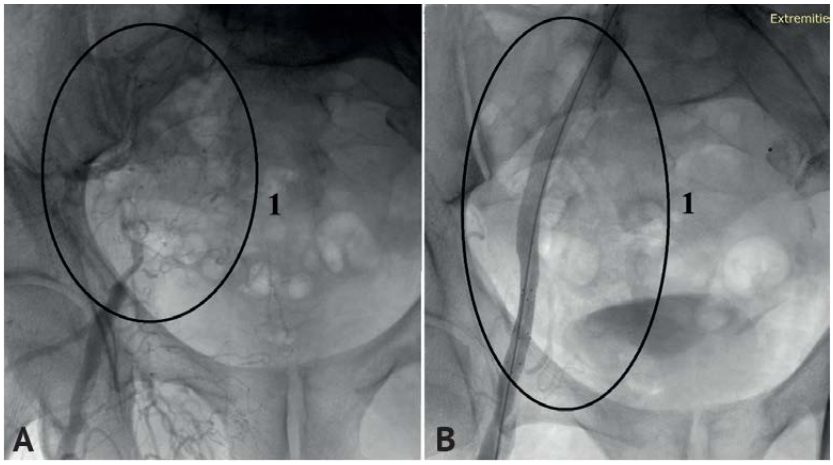

Fig. 1. Recanalization with stenting of the common and external iliac arteries of patient A. A — angiography before revascularization: 1 — the area of occlusion of the common and external iliac arteries (EIA) on the right; B — angiography after revascularization: 1 — implanted stents in the common and external iliac arteries, EIA

The patient was discharged from the hospital on the 3rd day after the intervention in a satisfactory condition.

Clinical example 2.

Patient B., male, 72 years old. Ten years ago, pain appeared in the left calf muscle when walking at a distance of 500 meters. At the time of this hospitalization, the pain-free walking distance decreased to 150 meters. From the anamnesis it is known that the patient has multiple insignificant stenoses of the coronary arteries, a month ago he underwent carotid endarterectomy on the right. According to the CDS data, 70% stenoses of the CIA and EIA were visualized on the left. Due to the presence of multifocal atherosclerosis with the risk of developing adverse cardiovascular events, as well as the age of the patient, a multidisciplinary team (cardiovascular surgeon, endovascular surgeon, cardiologist, anesthesiologist-resuscitator, neurologist) decided to implement endovascular correction of the identified lesion. The patient was hospitalized at the National Medical Research Center named after V.A. Almazov for angioplasty with stenting of the CIA and EIA on the left.

Operation progress. Under local anesthesia with 0.1% lidocaine solution (10 ml), the left CFA was punctured in a retrograde direction, a conductor Radiofocus 0,035" was introduced, 6F introducer was installed. Angiography was performed: left CIA stenosis 80%, left CFA stenosis 70%. A self-expanding stent was introduced and implanted into the affected area in the CIA, EIA Protge EverFlex 8x120 mm. Postdilatation with a balloon catheter POWERFLEX PRO 7x80 mm. At the control angiography: the area of stenting without residual stenoses, without dissections, without extravasations. Restored the main blood flow through the CIA, EIA.

The patient was discharged from the hospital on the 3rd day after the intervention in a satisfactory condition.

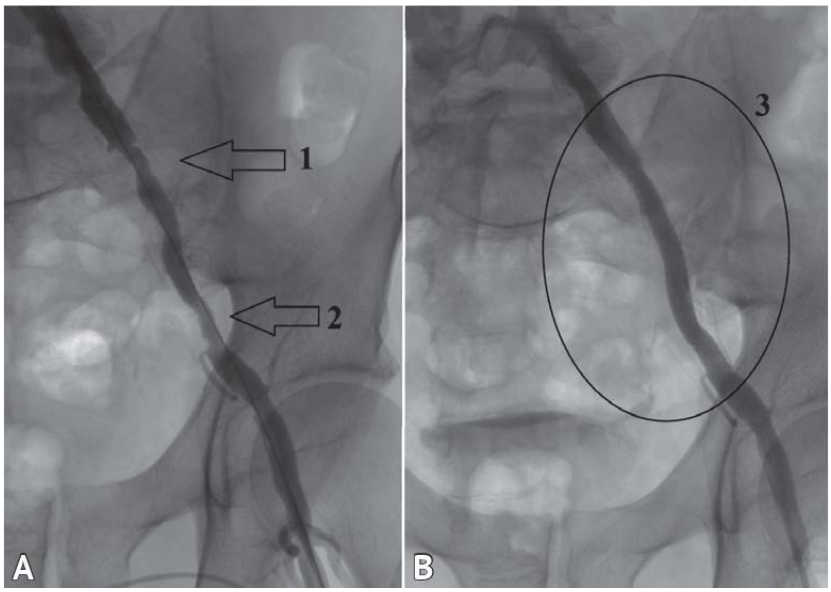

Fig. 2. Patient B: angioplasty with stenting of the external iliac artery and the common iliac artery on the left. A — angiography before revascularization: 1 — stenosis of the common iliac artery on the left; 2 — stenosis of the external iliac artery on the left; B — angiography after revascularization: 3 — implanted stent in the common iliac artery, external iliac artery on the left

CONCLUSION

The presented literature review and clinical examples demonstrate the safety and efficacy of endovascular technologies in the treatment of occlusive-stenotic lesions of the aortoiliac segment. The advantages of the method over open surgery are low trauma, no need for patient rehabilitation, the possibility of implementation in elderly patients with a pronounced comorbid background and multifocal atherosclerosis, no need for a long stay in a medical institution. Thus, interventional surgery can claim the status of the operation of choice for patients with atherosclerotic lesions of the aortoiliac segment.

REFERENCES

1. Kasemi H, Marino M, Dionisi CP, Di Angelo CL, Fadda GF. Seven-Year Approach Evolution of the Aortoiliac Occlusive Disease Endovascular Treatment. *Ann Vasc Surg*. 2016;30:277–285. PMID: 26370748 https://doi.org/10.1016/j.avsg.2015.07.016
2. Rutherford RB. Aortobifemoral bypass, the gold standard: technical considerations. *Semin Vasc Surg*. 1994;7(1):11–16. PMID: 8180750
3. Burkov NN, Kazantsev AN, Tarasov RS. In-Hospital Outcomes of Reconstructive Interventions on the Aortofemoral Segment in Patients with Multifocal Atherosclerosis. *Angiology and Vascular Surgery*. 2018;24(2):139–145. (in Russ.)
4. Burke CR, Henke PK, Hernandez R, Rectenwald JE, Krishnamurthy V, Englesbe MJ, et al. A contemporary comparison of aortofemoral bypass and aortoiliac stenting in the treatment of aortoiliac occlusive disease. *Ann Vasc Surg*. 2010;24(1):4–13. PMID: 20122461 https://doi.org/10.1016/j.avsg.2009.09.005
5. Ahn S, Park KM, Kim YK, Kim JI, Moon IS, Hong KC, et al. Outcomes of endovascular treatment for TASC C and D aorto-iliac lesions. *Asian J Surg*. 2017;40(3):215–220. PMID: 26787498 https://doi.org/10.1016/j.asjsur.2015.11.006
6. Yuan L, Bao J, Zhao Z, Feng X, Lu Q, Jing Z. Endovascular therapy for long-segment atherosclerotic aortoiliac occlusion. *J Vasc Surg*. 2014;59(3):663–668. PMID: 24239521 https://doi.org/10.1016/j.jvs.2013.09.005
7. Shval'b PG, Kalinin RE, Baranov SV, Suchkov IA, Pshennikov AS. Sravnitel'naya otsenka rezul'tatov rekonstruktivnykh operatsiy v aorto-podvzdoshnom segmente u bol'nykh s obliteriruyushchim aterosklerozom arteriy nizhnikh konechnostey. *Angiology and Vascular Surgery*. 2008;14(3):34–35. (in Russ.).
8. Burkov NN, Kazantsev AN, Anufriev AI, Danilovich AI, Smirnov KV, Lider RYu, et al. Femoropopliteal Reconstruction with "Kemangioprotez" Biological Prosthesis. *Russian Journal of Cardiology and Cardiovascular Surgery*. 2020;13(1):29–35. (in Russ.) https://doi.org/10.17116/kardio202013011129
9. Tshomba Y, Melissano G, Apruzzi L, Baccellieri D, Negri G, Chiesa R. Open repair for aortic occlusive disease: indication, techniques, results, tips and tricks. *J Cardiovasc Surg (Torino)*. 2014;55(2 Suppl 1):57–68. PMID: 24796898
10. Burkov NN, Kazantsev AN, Tarasov RS, Anufriev AI, Barbarash LS. Predictors of Adverse Reasons of Reconstructive Interventions on the Aorto-Femoral Segment in a Remote Period of Observation. *Russian Journal of Thoracic and Cardiovascular Surgery*. 2018;60(1):55–60. (in Russ.)
11. Ghoneim B, Elsherif M, Elsharkawi M, Acharya Y, Hynes N, Tawfick W, et al. Outcomes of Unibody Bifurcated Endograft and Aortobifemoral Bypass for Aortoiliac Occlusive Disease. *Vasc Specialist Int*. 2020;36(4):216–223. PMID: 33361542 https://doi.org/10.5758/vsi.200051
12. Magomedov SG, Djurakulov SR. Comparative Analysis of the Results of Endovascular and Open Interventions in the Defeat of Arteries Aorta-Iliac Segment. *Surgical practice*. 2018;(2):28–32. (in Russ.) https://doi.org/10.17238/issn2223-2427.2018.2.28-32

13. Burkov NN, Kazantsev AN, Tarasov RS, Anufriev AI, Barbarash LS. Five-Year Outcomes of Aorto-Femoral Vascular Reconstructions in Patients with Multifocal Atherosclerosis. *Pirogov Russian Journal of Surgery*. 2018;(5):13–18. (In Russ.). https://doi.org/10.17116/hirurgia2018513-18
14. Squizzato F, D'Oria M, Bozza R, Porcellato L, Grego F, Lepidi S. Propensity- Matched Comparison of Endovascular versus Open Reconstruction for TASC-II C/D AortoIliac Occlusive Disease. A Ten-Year Single-Center Experience with Self- Expanding Covered Stents. *Ann Vasc Surg*. 2021;71:84–95. PMID: 32927036 https://doi.org/10.1016/j.avsg.2020.08.139
15. Reijnen MM. Update on covered endovascular reconstruction of the aortic bifurcation. *Vascular*. 2020;28(3):225–232. PMID: 31896301 https://doi.org/10.1177/1708538119896197
16. Sixt S, Krankenberg H, Möhrle C, Kaspar M, Tübler T, Rastan A, et al. Endovascular treatment for extensive aortoiliac artery reconstruction: a single-center experience based on 1712 interventions. *J Endovasc Ther*. 2013;20(1):64–73. PMID: 23391085 https://doi.org/10.1583/12-4014.1
17. Zatevakhin II, Shipovskiy VN, Magomedov SG, Dzhurakulov SR. Endovascular treatment for iliac arteries atherosclerotic lesions. *Journal Diagnostic & interventional radiology*. 2010;4(2):29–37. (In Russ.)
18. Müller AM, Langwieser N, Bradaric C, Haller B, Fusaro M, Ott I, et al. Endovascular Treatment for Steno-Occlusive Iliac Artery Disease: Safety and Long-Term Outcome. *Angiology*. 2018;69(4):308–315. PMID: 28747061 https://doi.org/10.1177/0003319717720052
19. Norgren L, Hiatt WR, Dormandy JA, Nehler MR, Harris KA, Fowkes FG; TASC II Working Group, et al. Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). *Eur J Vasc Endovasc Surg*. 2007;33 Suppl 1:S1–75. PMID: 17140820 https://doi.org/10.1016/j.ejvs.2006.09.024
20. 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in Collaboration with the European Society for Vascular Surgery (ESVS). *Russian Journal of Cardiology*. 2018;(8):164–221. (in Russ.) https://doi.org/10.15829/1560-4071-2018-8-164-221
21. Indes JE, Pfaff MJ, Farrokhyar F, Brown H, Hashim P, Cheung K, et al. Clinical outcomes of 5358 patients undergoing direct open bypass or endovascular treatment for aortoiliac occlusive disease: a systematic review and meta-analysis. *J Endovasc Ther*. 2013;20(4):443–455. PMID: 23914850 https://doi.org/10.1583/13-4242.1
22. Grimme FA, Goverde PC, Verbruggen PJ, Zeebregts CJ, Reijnen MM. Editor's choice–first results of the covered endovascular reconstruction of the aortic bifurcation (CERAB) technique for aortoiliac occlusive disease. *Eur J Vasc Endovasc Surg*. 2015;50(5):638–647. PMID: 26343310 https://doi.org/10.1016/j.ejvs.2015.06.112
23. Dake MD, Ansel GM, Jaff MR, Ohki T, Saxon RR, Smouse HB, et al. Durable clinical effectiveness with paclitaxel-eluting stents in the femoropopliteal artery: 5-year results of the Zilver PTX randomized trial. *Circulation*. 2016;133(15):1472–1483. PMID: 26969758 https://doi.org/10.1161/CIRCULATIONAHA.115.016900
24. Anderson JL, Antman EM, Harold JG, Jessup M, O'Gara PT, Pinto FJ, et al. Clinical practice guidelines on perioperative cardiovascular evaluation: collaborative efforts among the ACC, AHA, and ESC. *Circulation*. 2014;130(24):2213–2214. PMID: 25085963 https://doi.org/10.1161/CIR.0000000000000103
25. Murphy TP, Cutlip DE, Regensteiner JG, Mohler ER, Cohen DJ, Reynolds MR, et al. Supervised exercise versus primary stenting for claudication resulting from aortoiliac peripheral artery disease: six-month outcomes from the Claudication: Exercise Versus Endoluminal Revascularization (CLEVER) study. *Circulation*. 2012;125(1):130–139. PMID: 22090168 https://doi.org/10.1161/CIRCULATIONAHA.111.075770
26. Natsional'nye rekomendatsii po diagnostike i lecheniyu zabolevaniy arteriy nizhnikh konechnostey 2019. Moscow, 2019. Available at: http://www.angiolsurgery.org/library/recommendations/2019/recommendations_LLA_2019.pdf [Accessed Nov 22, 2021]
27. Dellehunt RE, Manna B. Aortofemoral Bypass. 2021 Feb 20. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan. PMID: 31194468. Bookshelf ID: NBK542328
28. Katsuki T, Yamaji K, Hiramori S, Tomoi Y, Soga Y, Ando K. Ten-year clinical outcomes for patients undergoing lower extremity endovascular interventions. *J Vasc Surg*. 2020;72(5):1626–1635.e3. PMID: 32278575 https://doi.org/10.1016/j.jvs.2020.02.026
29. Premaratne S, Newman J, Hobbs S, Garnham A, Wall M. Meta-analysis of direct surgical versus endovascular revascularization for aortoiliac occlusive disease. *J Vasc Surg*. 2020;72(2):726–737. PMID: 32171442 https://doi.org/10.1016/j.jvs.2019.12.035
30. DeCarlo C, Boitano LT, Schwartz SI, Lancaster RT, Conrad MF, Eagleton MJ, et al. Laparotomy- and groin-associated complications are common after aortofemoral bypass and contribute to reintervention. *J Vasc Surg*. 2020;72(6):1976–1986. PMID: 32284209 https://doi.org/10.1016/j.jvs.2019.09.067
31. Mayor J, Branco BC, Chung J, Montero-Baker MF, Kougias P, Mills JL Sr, et al. Outcome Comparison between Open and Endovascular Management of TASC II D Aortoiliac Occlusive Disease. *Ann Vasc Surg*. 2019;61:65–71.e3. PMID: 31394230 https://doi.org/10.1016/j.avsg.2019.06.005
32. Yamauchi Y, Takahara M, Iida O, Shintani Y, Sugano T, Yamamoto Y, et al.; OMOTENASHI investigators. Independent predictors of loss of primary patency at 1 year after aortoiliac stent implantation. *Heart Vessels*. 2020;35(5):614–619. PMID: 31642981 https://doi.org/10.1007/s00380-019-01524-9
33. Nanto K, Iida O, Fujihara M, Yokoi Y, Tomoi Y, Soga Y, et al. Five- Year Patency and its Predictors after Endovascular Therapy for Aortoiliac Occlusive Disease. *J Atheroscler Thromb*. 2019;26(11):989–996. PMID: 30996200 https://doi.org/10.5551/jat.45617
34. Piffaretti G, Fargion AT, Dorigo W, Pulli R, Gattuso A, Bush RL, et al.; ILIACS Registry Group. Outcomes from the Multicenter Italian Registry on Primary Endovascular Treatment of Aortoiliac Occlusive Disease. *J Endovasc Ther*. 2019;26(5):623–632. PMID: 31331235 https://doi.org/10.1177/1526602819863081
35. Quan C, Kim DH, Jung HJ, Lee SS. Comparison of results between kissing stent and aortic bifurcated bypass in aortoiliac occlusive disease. *Asian J Surg*. 2020;43(1):186–192. PMID: 30852072 https://doi.org/10.1016/j.asjsur.2019.02.002
36. Zhang B, Niu G, Yan Z, Zou Y, Tong X, Yang M. Midterm outcomes of endovascular treatment with bare metal stents for Leriche syndrome patients. *Interact Cardiovasc Thorac Surg*. 2021;32(1):83–88. PMID: 33221834 https://doi.org/10.1093/icvts/ivaa223
37. Tshomba Y, Melissano G, Apruzzi L, Baccellieri D, Negri G, Chiesa R. Open repair for aortic occlusive disease: indication, techniques, results, tips and tricks. *J Cardiovasc Surg (Torino)*. 2014;55(2 Suppl 1):57–68. PMID: 24796898
38. Bracale UM, Giribono AM, Spinelli D, Del Guercio L, Pipitò N, Ferrara D, et al. Long-term Results of Endovascular Treatment of TASC C and D Aortoiliac Occlusive Disease with Expanded Polytetrafluoroethylene Stent Graft. *Ann Vasc Surg*. 2019;56:254–260. PMID: 30339903 https://doi.org/10.1016/j.avsg.2018.07.060

39. Liang HL, Li MF, Hsiao CC, Wu CJ, Wu TH. Endovascular management of aorto- iliac occlusive disease (Leriche syndrome). *J Formos Med Assoc*. 2021;120(7):1485–1492. PMID: 33189506 https://doi.org/10.1016/j.jfma.2020.10.033
40. Pomozi E, Lengyel B, Osztrogonácz P, Nguyen DT, Szeberin Z. Long-term analysis of the results of aorto-bifemoral bypass surgery for diffuse aorto-biiliac occlusive disease. *Orv Hetil*. 2021;162(3):99–105. Hungarian. PMID: 33459610 https://doi.org/10.1556/650.2021.31970
41. Gabel JA, Kiang SC, Abou-Zamzam AM Jr, Oyoyo UE, Teruya TH, Tomihama RT. Trans-Atlantic Inter-Society Consensus Class D Aortoiliac Lesions: A Comparison of Endovascular and Open Surgical Outcomes. *AJR Am J Roentgenol*. 2019;213(3):696–701. PMID: 31120778 https://doi.org/10.2214/AJR.18.20918
42. Zanabili Al-Sibbai AA, Camblor Santervás LA, Álvarez Marcos F, Rivas Domínguez M, Del Castro Madrazo JA, Llaneza Coto JM, et al. Midterm Results of Endovascular Treatment for Complete Iliac Axis Occlusions Using Covered Stents. *Ann Vasc Surg*. 2020;63:241–249. PMID: 31626933 https://doi.org/10.1016/j.avsg.2019.07.024
43. Cheng M, Lavi P, Tran-McCaslin M, Chun L, Lew W, Patel K. Aortoiliac Endarterectomy: A Useful Tool in Modern Vascular Practice. *Ann Vasc Surg*. 2020;68:572.e5–572.e7. PMID: 32445884 https://doi.org/10.1016/j.avsg.2020.04.077
44. Shen CY, Liu YF, Li QL, Zhang YB, Jiao Y, Krokidis ME, et al. Open and Endovascular Treatment of Trans-Atlantic Inter-Society Consensus II D Aortoiliac Occlusive Lesions: What Determines the Rate of Restenosis? *Chin Med J (Engl)*. 2015;128(22):3035–3042. PMID: 26608983 https://doi.org/10.4103/0366-6999.169053
45. Jia X, Guo W, Liu XP, Xiong J, Ma XH, Zhang HP, et al. The mid-term and long-term results of endovascular treatment of C/D aorto-iliac artery occlusive disease. *Zhonghua Yi Xue Za Zhi*. 2020;100(29):2273–2277. Chinese. PMID: 32746597 https://doi.org/10.3760/cma.j.cn112137-20200211-00251
46. Van Haren RM, Goldstein LJ, Velazquez OC, Karmacharya J, Bornak A. Endovascular treatment of TransAtlantic Inter-Society Consensus D aortoiliac occlusive disease using unibody bifurcated endografts. *J Vasc Surg*. 2017;65(2):398–405. PMID: 27765483 https://doi.org/10.1016/j.jvs.2016.08.084
47. Pereira-Macedo J, Machado N, Pereira-Neves A, Ferreira V, Oliveira-Pinto J, Dias-Neto M, et al. Myocardial injury after aortoiliac revascularization for extensive disease: A survival analysis. *Turk Gogus Kalp Damar Cerrahisi Derg*. 2020;28(3):426–434. PMID: 32953204 https://doi.org/10.5606/tgkdc.dergisi.2020.20100 eCollection 2020 Jul.
48. Rigatelli G, Zuin M, Dell'Avvocata F, Nanjundappa A, Daggubati R, Nguyen T. Non-invasive Evaluation of Fluid Dynamic of Aortoiliac Atherosclerotic Disease: Impact of Bifurcation Angle and Different Stent Configurations. *J Transl Int Med*. 2018;6(3):138–145. PMID: 30425950 https://doi.org/10.2478/jtim-2018-0020 eCollection 2018 Sep.
49. Papoyan SA, Shchegolev AA, Gromov DG, Kvitsaridze BA, Sazonov MYu, Gavrilenko AV. Results of Endovascular Treatment of Patients With Type C and D Lesions of the Aortoiliac Segment According to the TASC II Classification. *Angiology and Vascular Surgery*. 2016;22(3):75–59. PMID: 27626253 (in Russ.)
50. Reijnen MM. Update on covered endovascular reconstruction of the aortic bifurcation. *Vascular*. 2020;28(3):225–232. PMID: 31896301 https://doi.org/10.1177/1708538119896197
51. Ghoneim B, Elsherif M, Elsharkawi M, Acharya Y, Hynes N, Tawfick W, et al. Outcomes of Unibody Bifurcated Endograft and Aortobifemoral Bypass for Aortoiliac Occlusive Disease. *Vasc Specialist Int*. 2020;36(4):216–223. PMID: 33361542 https://doi.org/10.5758/vsi.200051
52. Ahn S, Park KM, Kim YK, Kim JI, Moon IS, Hong KC, et al. Outcomes of endovascular treatment for TASC C and D aorto-iliac lesions. *Asian J Surg*. 2017;40(3):215–220. PMID: 26787498 https://doi.org/10.1016/j.asjsur.2015.11.006
53. Yuan L, Bao J, Zhao Z, Feng X, Lu Q, Jing Z. Endovascular therapy for long- segment atherosclerotic aortoiliac occlusion. *J Vasc Surg*. 2014;59(3):663–668. PMID: 24239521 https://doi.org/10.1016/j.jvs.2013.09.005
54. Balzer KM, Weis-Müller BT. Results of open vascular surgical therapy in chronic peripheral arterial disease. *Vasa*. 2011;40(5):359–367. PMID: 21948778 https://doi.org/10.1024/0301-1526/a000132
55. Ruggiero NJ 2nd, Jaff MR. The current management of aortic, common iliac, and external iliac artery disease: basic data underlying clinical decision making. *Ann Vasc Surg*. 2011;25(7):990–1003. PMID: 21784611 https://doi.org/10.1016/j.avsg.2011.05.003
56. Oertli D, Waibel P. Die Thrombendarterectomy in aorto-iliac occlusive disease. *Schweiz Med Wochenschr*. 1995;125(22):1075–1081. German. PMID: 7784869
57. Harris RA, Hardman DT, Fisher C, Lane R, Appleberg M. Aortic reconstructive surgery for limb ischaemia: immediate and long-term follow-up to provide a standard for endovascular procedures. *Cardiovasc Surg*. 1998;6(3):256–261. PMID: 9705097 https://doi.org/10.1016/s0967-2109(97)00150-6
58. Squizzato F, D'Oria M, Bozza R, Porcellato L, Grego F, Lepidi S. Propensity- Matched Comparison of Endovascular versus Open Reconstruction for TASC-II C/D AortoIliac Occlusive Disease. A Ten-Year Single-Center Experience with Self- Expanding Covered Stents. *Ann Vasc Surg*. 2021;71:84–95. PMID: 32927036 https://doi.org/10.1016/j.avsg.2020.08.139

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