Review
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Surgical Treatment of Varicose Veins of the Lower Extremities

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ABSTRACT The review presents an analysis of relevant literature on the surgical treatment of varicose veins of the lower extremities. Modern methods of surgical intervention for varicose veins are considered: open operations, methods of thermal ablation of the main veins, non-thermal non-tumescent methods, vein-preserving surgery (ASVAL), methods of treating reflux in perforating veins and recurrent varicose veins. The effectiveness of each of the surgical treatment methods used was analyzed. The frequency of relapses and the likelihood of complications of the described operations are considered. All surgical treatment methods presented in the review were developed on the basis of modern ideas about the pathogenesis of varicose veins, the mechanisms of formation of chronic venous insufficiency, and have an evidence base. These techniques are reflected in the latest clinical guidelines and are widely used in medical practice.

Keywords: varicose veins, thermal ablation of varicose veins, non-thermal non-tumescent methods, mini-phlebectomy, recurrent varicose veins

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ASVAL – ablation selective des varices sous anesthesia locale
CVI – chronic venous insufficiency
DVT – deep vein thrombosis
EVLO – endovenous laser obliteration
GSV – great saphenous vein
NTNT – non-thermal non-tumescent methods
PE – pulmonary embolism
PV – perforating veins
RFO – radiofrequency obliteration
SSV – small saphenous vein
VAS – visual analogue scale
VTEC – venous thromboembolic complications
VVLE – varicose veins of the lower extremities

INTRODUCTION

Varicose veins of the lower extremities (VVLE) is a widespread and actively discussed disease these days. The incidence of VVLE reaches 40–50% in adults [1, 2]. In Russia, symptoms inherent in chronic venous insufficiency (CVI) were identified in 69.3% of adults [3]. The specialized surgical treatment is indicated for most patients with VVLE, which is 25–35% among adult women, 10–30% among men [4].

VVLE surgery has undergone a number of major changes over the past 20 years. The desire to minimize trauma and mobilize the patient as early as possible has led to a shift in the course of surgery towards minimally invasive procedures that can be performed outpatient or in one-day hospitals. Thus, today thermal methods of endovenous obliteration are considered the gold standard in the surgical treatment of VVLE [5, 6]. However, the search for ways

to improve surgical results, the desire to avoid a number of manipulations and increase patient comfort lead to the latest developments, such as, for example, non-thermal non-tumescent methods (NTNT).

The article presents a thematic review of the literature on modern surgical methods for treating VVLE.

MODERN IDEAS ABOUT THE ETIOLOGY AND PATHOGENESIS OF VARICOSE VEINS

Currently, VVLE is recognized as a multifactorial disease, and the etiopathogenesis of VVLE has been studied in detail, which has made it possible to formulate certain principles for the treatment and prevention of this disease [7].

In matters of the etiology of VVLE, the greatest attention is given to genetic predisposition [8]. Thus, the FOXC2 gene, which encodes a transcription factor necessary for the development of venous and lymphatic vessels in the embryonic and postnatal periods, has been well studied. The formation of mutations in this gene can lead to disruption of the connective tissue in the walls of the superficial veins, which is confirmed by the detected increased expression of FOXC2 in patients with VVLE [9, 10].

A major role in the initiation of VVLE and its early manifestation is given to the MCP1 gene, which encodes the synthesis of a monocyte chemoattractant protein. In addition, the role of the VEGF and HFE genes in the development of CVI has now been shown [8, 11].

The complex influence of various factors leads to varicose transformation of congenitally weakened veins. When considering the progression of pathological varicose veins and venous stasis, attention should be paid to both processes occurring at the cellular level and macrohemodynamics. Thus, it has been studied that venous stasis leads to certain disturbances in endothelial cells due to changes in shear force [12], as a result of which mechanisms are activated (adhesion of leukocytes and various protein molecules, synthesis of a number of proteolytic enzymes by endothelial cells, etc.) that trigger a cascade of inflammatory changes, which ultimately leads to destructive processes in the venous wall and valves [13, 14].

It is important to note that all elements of the venous wall are affected as the disease progresses; microscopic examination reveals destruction of elastic and collagen fibers. Due to the fact that valves are modified elements of the venous wall, their destruction occurs synchronously with other elements [15].

Thus, it has been established that the final stage that stops the functioning of the veins is destruction, which is an irreversible process. And if at the initial stage of the disease conservative treatment can still be used, then with further development we are talking only about surgical elimination of these veins [7, 16].

GOALS OF SURGICAL TREATMENT OF VARICOSE VEINS

The goals of surgical treatment of VVLE are: elimination of the cosmetic defect and reduction of the severity or elimination of symptoms of CVI. To achieve these goals, the following tasks are surgically solved: elimination of pathological vertical and (or) horizontal reflux and elimination of varicose saphenous veins. Thus, surgical intervention combines the elimination of incompetent great or small saphenous veins, sometimes the Giaccomini vein or anterior accessory saphenous vein (vertical reflux), perforating veins (PV) (horizontal reflux) in combination with the removal of varicose saphenous tributaries [5, 17].

Currently, various technologies for the surgical treatment of varicose veins have been developed. Elimination of reflux is possible through open surgery, thermal obliteration and NTNT methods. According to national recommendations, none of the methods is mandatory; in addition, any stage can be performed in isolation [5].

OPEN INTERVENTIONS

For a long time, the issue of pathological reflux along the great saphenous vein (GSV) was resolved through open surgery: phlebectomy or Babcock stripping. In this case, a crossectomy of the GSV orifice was performed and its extraction using a vein extractor through a second access. Varicose tributaries were removed from separate incisions according to Narat from punctures (mini-phlebectomy) or were subjected to sclerosis. However, surgical trauma, cosmetic disadvantages and the possibility of surgical complications of phlebectomy, the need for spinal or general anesthesia contributed to the development and implementation of minimally invasive technologies [18].

Currently, open surgical methods are recommended only in cases where it is technically or financially impossible to perform thermal methods [5]. A number of studies have shown the advantage of using inguinal or supra-inguinal approaches [19, 20]. Invagination stripping (including PIN stripping) is indicated as the optimal

method for removing the GSV. These methods involve the use of probes with tips of small diameters or special PIN strippers, during the traction the vein is twisted inward, which reduces trauma to surrounding tissues [17, 21].

A number of studies have shown that in 80–90% of cases, reflux along the GSV is observed maximally only to the level of the upper third of the leg [19, 22]. Therefore, venous extraction is recommended to be performed precisely to this level [5]. The incidence of damage to the tibial nerves with such a "short" stripping is lower than with complete removal of the GSV, and the frequency of recurrences of the GSV does not increase [23].

It is also currently believed that stripping of the GSV can be performed on an outpatient under local anesthesia, which can reduce the rehabilitation time for patients [24, 25].

ENDOVENOUS THERMAL METHODS

Currently, minimally invasive thermal treatment methods are widely introduced into surgical practice: endovasal laser obliteration (EVLO) and radiofrequency obliteration (RFO). These methods are recognized as the gold standard in eliminating pathological reflux in VVLE and are recommended as preferable to open surgical treatment and scleral obliteration [5, 19, 26, 27]. In the Russian-language literature, various terms are used that are recognized as synonyms: "coagulation", "obliteration" and "ablation".

Thermal obliteration is based on endovasal thermal damage to the venous wall, which leads to occlusive fibrosis and transformation of the vein into a connective tissue cord. Thus, the vein as a morphological structure ceases to exist [28, 29].

When choosing between EVLO and RFO, none of these methods is recommended as preferable, since no significant differences have been obtained between these two methods in terms of effectiveness and long-term results [5, 30]. The results of five-year observations demonstrated the frequency of GSV obliteration of 92.2% for EVLO and 91.9% for RFO [20, 30–32]. In a number of studies, one can find information about an increased level of postoperative pain for EVLO. But it is worth noting that they were carried out for short-wave laser radiation and end-face fibers [30, 33, 34]. Currently, in the vast majority of cases, devices with long wavelength radiation, flexible light guides with Radial and 2 ring tips are used . New generation lasers emit wavelengths up to 2 microns. Thanks to the equipment described above, it is possible to achieve fibrosis of veins of various sizes with minimal pain [35, 36].

Currently, it is not recommended to supplement thermal methods of vein obliteration with crossectomy. Thus, in 2013, specialists from Germany demonstrated in their study that performing crossectomy together with EVLO of the GSV trunk does not reduce the risk of VVLE recurrence in the long term [37].

Several systems have been developed to carry out RFO. The most widely used system is ClosureFAST (now Venefit). Now in the Russian-language literature, due to the popularity of this catheter, one can find the terms RFO and Venefit being identified. Other RFO systems have also been developed, such as RFiTT and EVFR. In fact, the mechanisms of action on surrounding tissues for these technologies are different: monopolar, bipolar, differences in power and thermal heating. The evidence base for the last two technologies is insufficient and is presented only in foreign literature [38–40]. Modern clinical recommendations are based specifically on studies of the Venefit RFO system [5].

The question of the risk of venous thromboembolic complications (VTEC) becomes logical. Thus, a systematic review of publications on thermoobliteration of veins indicated the absence of reports of fatal complications, and the incidence of severe VTEC did not exceed 1% [41]. At the same time, the incidence of VTEC after combined phlebectomy reaches 5.3% [42]. According to Barker et al. the incidence of VTEC after combined phlebectomy and endovenous methods was 0.15–0.35% in the first 30 days, 0.26–0.50% within 90 days and 0.46–0.58% within 1 year [43] .

The considered methods of thermoobliteration have practically no contraindications. They can be performed even in the presence of a trophic ulcer, but in the absence of purulent discharge and when the acute inflammatory process subsides. However, a number of conditions limit the use of these techniques. Such conditions include situations in which it is impossible to wear compression hosiery (obliterating diseases of the lower extremities with an ankle-brachial index less than 0.5), deep vein thrombosis (DVT) and decompensated somatic pathology. Relative contraindications are uncontrolled swelling of the legs, which impedes ultrasound visualization of the veins, pregnancy, and an increased risk of VTEC, which can be calculated using the Caprini scale [5, 44].

NON-THERMAL NON-TUMESCENT METHODS

Currently, the number of publications on the use of NTNT to eliminate vertical reflux is growing. The proliferation of NTNT is logical in the era of trauma minimization. The most actively developing method of NTNT is the method of cyanoacrylate obliteration of the trunk of the GSV or the small saphenous vein (SSV). The fundamental differences between this method of eliminating vertical reflux and thermal methods are the absence of the need to use tumescent anesthesia and compression stockings [19].

The essence of the technique is to obliterate the incompetent venous trunk with glue based on N-butyl ester of α-cyanoacrylic acid under ultrasound guidance using special delivery systems. Several systems consisting of catheters and adhesive dispensers have been developed in the world: VenaSeal (USA), VenaBlock (Turkey), VariClose (Turkey), Venex (Turkey), etc. [45]. Only the VenaSeal system is currently registered in Russia. The results of using this system, indicating high efficiency, are presented in a number of domestic publications [46, 47], however, due to the high cost, VenaSeal has not found widespread use in domestic practice. In Russia, a domestic development, Sulfacrylate, is of great interest. This adhesive composition is synthesized on the basis of ethyl ester of α-cyan acrylic acid. Studies have shown the safety and high effectiveness of Sulfacrylate in the treatment of varicose veins. In addition, the different chemical structure of Sulfacrylate makes it less viscous and capable of biodegradation [48–50].

Various studies indicate that the incidence of vein occlusion with cyanoacrylate glue in 6 months is 90–95%, 95.8% in a year, 94.7% in 3 years [30, 51, 52]. The largest systematic review of studies on cyanoacrylate obliteration today included 13 studies, 1,267 interventions were performed on the GSV and 254 procedures were performed on the SSV [53].

In a randomized clinical trial (RCT) of thermal methods and cyanoacrylate obliteration with a follow-up period of 12 months, there were no significant differences in the incidence of vein occlusions [49, 51]. Also, according to a 2021 network meta-analysis, no significant differences in relapse rates were found between NTNT and thermal methods [54].

Studies comparing the domestic development of Sulfacrylate and the American VenaSeal system demonstrate no worse results both in the frequency of vein occlusions and in the frequency and severity of complications [55, 56].

An important advantage of NTNT, which is noted in all studies, is the low level of pain during the procedure and in the early postoperative period. According to Morrison et al., intraoperative pain level on the visual analogue scale (VAS) during adhesive obliteration was 2.2, while during RFO it reached 2.4 [53]. Bozkurt et al. conducted a similar comparison of NTNT with EVLO. At the same time, for adhesive obliteration it was 3.1, for EVLO it was 6.2 according to VAS [30].

To date, no cases of DVT and pulmonary embolism (PE) after adhesive obliteration have been recorded [30, 52, 55].

ELIMINATION OF REFLUX THROUGH PERFORATOR VEINS

Indications for eliminating PV are determined by the type of reflux, the size of the dilated PV and the clinical picture. It is important to note that in order to objectively detect reflux along the PV, ultrasound examination should be performed while standing [58]. It is indicated to carry out interventions on PVs with a diameter of more than 3.5 mm with a reflux duration of more than 0.5s. Moreover, their location should correspond to the area of trophic disturbances (classes C4, C5 and C6) [5, 19]. A number of experts question the effectiveness of eliminating PV for classes C2 and C3, as well as in the complex of surgical treatment for the elimination of vertical reflux [58, 59].

To eliminate incompetent PVs, various techniques can be used: suprafascial ligation, their destruction using vein extractor hooks, endoscopic dissection (SEPS), scleroteroobliteration, laser or radiofrequency obliteration under ultrasound guidance [5, 60, 61]. Ligation of the PV (open or using submurged ligation) is an effective technique, but has limitations in conditions of trophic changes in the skin. In this case, thermoobliteration or ultrasound-guided scleroobliteration are preferable. These techniques show an effectiveness of up to 80–85% over a follow-up period of 5 years [61].

Endoscopic subfascial dissection of the PV and open dissection (Linton-Felder method) are currently significantly limited. Endoscopic dissection is reflected in clinical recommendations in cases where other methods are ineffective. The second technique has lost its place in trauma recommendations [5, 62].

ASVAL METHOD

In 2005, P. Pittaluga et al. reported high effectiveness of vein-sparing surgery [63]. The authors called the method of removing varicose saphenous veins leaving the incompetent trunk of the GSV ASVAL (Ablation Selective des Varices sous Anesthesie Locale). This term is firmly entrenched in phlebological circles.

The removal of the saphenous veins is performed under local infiltration anesthesia using special phlebectomy hooks (microphlebectomers). There are various modifications of microphlebextractors: Varady, Muller, Oesch. The choice of hook is based on the surgeon's preferences. Skin punctures are made with a 16 G –18 G needle or a scalpel blade (incisions are made up to 2 mm long) with preoperative marking of varicose veins. Hemostasis is carried out using the elastic compression method [5, 64].

Mid-term results of prospective studies demonstrated the disappearance of reflux in 67–70% of cases with a decrease in the diameter of the GSV in 100% of cases. Moreover, the fincidence of recurrence of varicose veins reached 10–12%, and complications in the form of thrombosis of the main trunk amounted to 1–5% [65, 66]. At the same time, M. Biemans et al. did not report any complications of the procedure [67].

These results allowed the authors to express confidence in the previously put forward "ascending theory" of the formation of reflux: dilation of the tributaries is accompanied by a local decrease in pressure in them during the diastole of the muscular-venous pump of the leg, which creates conditions for the reverse movement of blood along the main trunk down to the dilated tributary, forming reflux [68–70]. Currently, the ASVAL technique is causing a number of discussions about the appropriateness of its use. This is due to both the large number of adherents of the "descending" theory of reflux and adherents of trunk obliteration of the great veins, and the rather low (no more than 70%) frequency of disappearance of reflux and the high frequency of relapses in patients who have undergone ASVAL. However, proponents of ASVAL note that studies in this area require clear inclusion criteria regarding the diameter of the incompetent GSV and the lower limit of reflux. They also note a high probability of multifocal origin of reflux, which may cause its persistence in a third of cases [65, 66, 71]. At the same time, it is noted that the frequency of relapses of varicose veins of the saphenous veins with ASVAL does not exceed the frequency of relapses with stem thermal obliteration or stripping of the GSV, which is probably a consequence of both the genesis of the varicose veins itself and the ways in which reflux is formed [25, 72].

Currently, ASVAL is noted in clinical recommendations for the treatment of patients with varicose veins and can be considered both as an independent method and as part of a set of measures in the treatment of varicose veins [5].

SURGERIES FOR RECURRENT VARICOSE VEINS

Recurrence of VVLE can develop for several reasons, the major reasons are the natural progression of the disease and residual veins that developed as a result of a tactical or technical error [73].

Tactical errors include maintaining an incompetent GSV (or SSV) or leaving varicose tributaries in the hope of their disappearance. Performing ASVAL or separation miniphlebectomy and trunk obliteration is not considered an error. Technical errors are actions performed directly during surgical treatment that led to relapse. Such errors include, for example, violations of the protocol for endovasal obliteration methods (creating a "weak" sheath during tumescent anesthesia, creating a weak energy concentration, incorrect calculations of the sclerosant during trunk scleral obliteration), which leads to recanalization of the main venous trunk. Leaving a large stump of the GSV during phlebectomy or poor treatment of tributaries during crossectomy leads to the formation of reflux along the left estuary tributaries of the GSV and, as a consequence, relapse of the GSV [5].

Undoubtedly, to identify the cause of VVLE relapse, determine the configuration of existing pathological veins, the patency of the deep veins of the lower extremities and, of course, determine the full treatment tactics, duplex ultrasound scanning is mandatory [74].

In case of preservation of the stump or segment of the GSV or SSV, open surgery, despite its effectiveness, is not recommended. This is associated with a high risk of adverse complications, in particular damage to adjacent nerves, and infectious complications [20, 28, 72]. The results of randomized controlled trials show equal effectiveness of endovenous thermoobliteration methods compared with open surgical interventions in correcting relapse. However, the incidence of complications when using endovenous methods is lower [74–76]. Such data allow us to call endovasal methods the methods of choice for this pathology. With their help, it is possible to achieve obliteration of the stump of the GSV or SPV, the Giaccomini vein (if it is the source of reflux) and other veins.

When recurrent varicose veins are excessively tortuosity, the use of thermoobliteration can be technically difficult. In this case, treatment is carried out using foam sclerotherapy. Ultrasound guidance is used for sclerobliteration of deep veins. This method is well applicable not only for eliminating reflux from deep to superficial veins, but also for eliminating varicose saphenous veins. Trunk scleral obliteration of the main veins is also used in their postthrombophlebitic syndrome due to recanalization after endovenous obliteration, when the installation of a light guide can be problematic. This method is characterized by its simplicity and the possibility of performing it in stages, as well as the possibility of combination with other methods of correction of varicose veins [77–79]. Another undoubted advantage of the method is its relatively low cost, which in some cases determines its use in primary VVLE [5].

In order to eliminate recurrent varicose saphenous veins in the absence of large trunks or reliably identified incompetent perforating veins, isolated mini-phlebectomy can be used [79]. The above methods for correcting recurrent VVLE can be performed on an outpatient basis and are associated with a short rehabilitation period [5].

CONCLUSION

Modern advances in the study of the pathogenesis of varicose veins of the lower extremities, increasing the competence of surgical specialists in the methods of diagnosing and identifying the causative factors of varicose veins of the lower extremities make it possible to provide surgical care to patients at any stage of the disease: from the occurrence of subcutaneous varicose nodes to the formation of vertical or horizontal reflux. Modern methods of surgical treatment of varicose veins of the lower extremities are aimed not only at accurately eliminating the symptoms of the disease and preventing their causes, but minimizing surgical invasiveness as well, reducing the likelihood of relapses and shortening the rehabilitation period.

REFERENCES

1. Robertson L, Evans C, Fowkes F. Epidemiology of chronic venous disease. Phlebology. 2008;23(3):103–111. PMID: 18467617 https://doi.org/10.1258/phleb.2007.007061
2. Rabe E, Guex JJ, Puskas A, Scuderi A, Fernandez Quesada F; VCP Coordinators. Epidemiology of chronic venous disorders in geographically diverse populations: results from the Vein Consult Program. Int Angiol . 2012;31(2):105–115. PMID: 22466974
3. Savel'ev VS, Kirienko AI, Zolotukhin IA, Seliverstov EI, Prospective observational study SPECTRUM: the registry of patients with chronic venous diseases. Flebologiya . 2012;6(1):4–9. (In Russ.).
4. Khitar'ian AG, Orekhov AA, Ledenev AA, Voronova OV, Shatov DV, Veliyev KS. Treatment of Venous Ulcer Related to Acquired Arteriovenous Fistula. Flebologiya . 2020;14(2):155–160. (In Russ.) https://doi.org/10.17116/flebo202014021155
5. Kamaev AA, Bulatov VL, Vakhratyan PE, Volkov AM, Volkov AS, Gavrilov EK, et al. Varicose Veins. Flebologiya . 2022;16(1):41–108. (In Russ.) https://doi.org/10.17116/flebo20221601141
6. Borsuk DA, Fokin AA. Possibilities of Using the Colibri System for Endovenous Laser Ablation. Angiology and Vascular Surgery. 2020;26(2):103–108. (In Russ.) https://doi.org/10.33529/ANGI02020205
7. Kalinin RE, Suchkov IA, Kamaev AA, Mzhavanadze ND. Duration of Treatment with Phlebotonics in Patients With Chronic Venous Disease. Angiology and Vascular Surgery. 2020;26(3):60–67. (In Russ.) https://doi.org/10.33529/ANGI02020301
8. Shadrina A, Tsepilov Y, Sokolova E, Smetanina M, Voronina E, Pakhomov E, et al. Genome-wide association study in ethnic Russians suggests an association of the MHC class III genomic region with the risk of primary varicose veins. Gene. 2018;659:93–99. PMID: 29551506 https://doi.org/10.1016/j.gene.2018.03.039
9. Bharath V, Kahn SR, Lazo-Langner A. Genetic polymorphisms of vein wall remodeling in chronic venous disease: A narrative and systematic review. Blood . 2014;124(8):1242–1250 PMID: 25006132 https://doi.org/10.1182/blood-2014-03-558478
10. Shadrina AS, Zolotukhin IA, Filipenko ML. Molecular Mechanisms Underlying the Development of Varicose Veins of Low Extremities. Flebologiya . 2017;11(2):71–75. (In Russ.) https://doi.org/10.17116/flebo201711271-75
11. Markovic JN, Shortell CK. Genomics of varicose veins and chronic venous insufficiency. Semin Vasc Surg. 2013;26(1):2–13. PMID: 23932556 https://doi.org/10.1053/j.semvascsurg.2013.04.003
12. Fitts MK, Pike DB, Anderson K, Shiu YT. Hemodynamic Shear Stress and Endothelial Dysfunction in Hemodialysis Access. Open Urol Nephrol J 2014;7(1):33–44. PMID: 25309636 https://doi.org/10.2174/1874303X01407010033
13. Raffetto JD. Dermal pathology, cellular biology, and inflammation in chronic venous disease. Thromb Res. 2009;123(Suppl 4):66–71. PMID: 25309636 https://doi.org/10.1016/S0049-3848(09)70147-1
14. Perrin M, Ramelet AA. Pharmacological Treatment of Primary Chronic Venous Disease: Rationale, Results and Unanswered Questions. Eur J Vasc Endovasc Surg . 2011;41(1):117–125. PMID: 21126890 https://doi.org/10.1016/j.ejvs.2010.09.025
15. Aunapuu M, Arend A. Histopathological changes and expression of adhesion molecules and laminin in varicose veins. Vasa. 2005;34(3):170–175. PMID: 16184835 https://doi.org/10.1024/0301-1526.34.3.170
16. Zolotukhin IA, Gavrilov SG, Kirienko AI. Phlebology Today. Annals of Surgery (Russia). 2016;21(1–2):19–25. (In Russ.) https://doi.org/10.18821/1560-9502-2016-21-1-19-25
17. Krylov AYu, Shulutko AM, Khmyrova SE, Osmanov EG, Gogokhiya TR, Petrovskaya AA. Varicose Syndrome Correction in Complex Treatment of Lower Limb Varicose Veins. Flebologiya . 2020;14(4):336–344. (In Russ.) https://doi.org/10.17116/flebo202014041336
18. Böhler K. [Surgery of varicose vein insufficiency]. Wien Med Wochenschr . 2016;166(9–10):293–296. (In German). PMID: 27405862 https://doi.org/10.1007/s10354-016-0486-6

19. Nicolaides A, Kakkos S, Baekgaard N, Comerota A, de Maeseneer M, Eklof B, et al. Management of chronic venous disorders of the lower limbs. Guidelines According to Scientific Evidence. Part II. Int Angiol . 2020;39(3):175–240. PMID: 32214074 https://doi.org/10.23736/S0392-9590.20.04388-6
20. Wittens C, Davies AH, Bækgaard N, Broholm R, Cavezzi A, Chastanet S, et al. Editor's Choice - Management of Chronic Venous Disease: Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg . 2015;49(6):678–737. PMID: 25920631 https://doi.org/10.1016/j.ejvs.2015.02.007
21. Cronenwett JL, Johnston KW. Rutherford's Vascular Surgery. Philadelphia, PA: Saunders/Elsevier; 2014.
22. Rabe E, Pannier F. Clinical, Aetiological, Anatomical and Pathological Classification (Ceap): Gold Standard and Limits. Phlebology . 2012;27(1 Suppl):114–118. PMID: 22312077 https://doi.org/10.1258/phleb.2012.012s19
23. Winterborn RJ, Foy C, Earnshaw JJ. Causes of varicose vein recurrence: late results of a randomized controlled trial of stripping the long saphenous vein. J Vasc Surg. 2004;40(4):634–639. PMID: 15472588 https://doi.org/10.1016/j.jvs.2004.07.003
24. Creton D, Réa B, Pittaluga P, Chastanet S, Allaert FA. Evaluation of the pain in varicose vein surgery under tumescent local anesthesia using sodium bicarbonate as excipient without any intravenous sedation. Phlebology. 2012;27(7):368–373. PMID: 22106448 https://doi.org/10.1258/phleb.2011.011026
25. Rasmussen L, Lawaetz M, Bjoern L, Blemings A, Eklof B. Randomized clinical trial comparing endovenous laser ablation and stripping of the great saphenous vein with clinical and duplex outcome after 5 years. J Vasc Surg. 2013;58(2):421–426. PMID: 23768792 https://doi.org/10.1016/j.jvs.2012.12.048
26. Somasundaram SK, Weerasekera A, Worku D, Balasubramanian RK, Lister D, Valenti D, et al. Office Based Endovenous Radiofrequency Ablation of Truncal Veins: A Case for Moving Varicose Vein Treatment out of Operating Theatres. Eur J Vasc Endovascular Surg. 2019;58(3):410–414. PMID: 31351830 https://doi.org/10.1016/j.ejvs.2019.05.020
27. Kawai Y, Sugimoto M, Aikawa K, Komori K. Endovenous Laser Ablation with and Without Concomitant Phlebectomy for the Treatment of Varicose Veins: A Retrospective Analysis of 954 Limbs. Ann Vasc Surg. 2020;66:344–350. PMID: 31917221 https://doi.org/10.1016/j.avsg.2019.12.025
28. Carradice D, Leung C, Chetter I. Laser; best practice techniques and evidence. Phlebology. 2015;30(2 Suppl):36–41. PMID: 26556701 https://doi.org/10.1177/0268355515591440
29. Vuylsteke ME, Klitfod L, Mansilha A. Endovenous ablation. Int Angiol. 2019;38(1):22–38. PMID: 30465420 https://doi.org/10.23736/S0392-9590.18.04047-6
30. Shaĭdakov EV, Iliukhin EA, Petukhov AV, Grigorian AG, Rosukhovskiĭ DA. Endovenous radiofrequency obliteration with the ClosureFAST procedure versus 1470-nm laser ablation for the treatment of great saphenous venous reflux: a multicenter prospective non-randomized study. Flebologiya . 2012;6(3):20–27. (In Russ.).
31. Bozkurt AK, Ylmaz MF. A prospective comparison of a new cyanoacrylate glue and laser ablation for the treatment of venous insufficiency. Phlebology . 2016;31(1 Suppl):106–113. PMID: 26916777 https://doi.org/10.1177/0268355516632652
32. Proebstle TM, Alm BJ, Göckeritz O, Wenzel C, Noppeney T, Lebard C, et al. Five-year results from the prospective European multicentre cohort study on radiofrequency segmental thermal ablation for incompetent great saphenous veins. Br J Surg . 2015;102(3):212–218. PMID: 25627262 https://doi.org/10.1002/bjs.9679
33. Nordon IM, Hinchliffe RJ, Brar R, Moxey P, Black SA, Thompson MM, et al. Prospective Double-Blind Randomized Controlled Trial of Radiofrequency Versus Laser Treatment of the Great Saphenous Vein in Patients with Varicose Veins. Ann Surg . 2011;254(6):876–881. PMID: 21934487 https://doi.org/10.1097/SLA.0b013e318230af5a
34. Volkov AS, Dibirov MD, Shimanko AI, Gadzhimuradov RU, Tsuranov SV, Shvydko VS, et al. Comparison of Endovasal Laser and Radiofrequency Ablation of Great Saphenous Vein in the Complex Treatment of Lower Limb Varicose Vein Disease. Flebologiya . 2020;14(2):91–98. (In Russ.) https://doi.org/10.17116/flebo20201402191
35. Belyaev AN, Ryabochkina PA, Kostin SV, Bushukin OS, Khrushchalin SA, Belyaev SA. Vein wall changes after 1910 nm laser coagulation with bare-fiber and radial fiber. Flebologiya . 2021;15(3):154–161. (In Russ.) https://doi.org/10.17116/flebo202115031154
36. Hirokawa M, Ogawa T, Sugawara H, Shokoku S, Sato S. Comparison of 1470 nm Laser and Radial 2 ring Fiber with 980 nm Laser and Bare-Tip Fiber in Endovenous Laser Ablation of Saphenous Varicose Veins: A Multicenter, Prospective, Randomized, Non-Blind Study. Ann Vasc Dis . 2015;8(4):282–289. PMID: 26730252 https://doi.org/10.3400/avd.oa.15-00084
37. Flessenkämper I, Hartmann M, Stenger D, Roll S. Endovenous laser ablation with and without high ligation compared with high ligation and stripping in the treatment of great saphenous varicose veins: initial results of a multicentre randomized controlled trial. Phlebology . 2013;28(1):16–23. PMID: 22451455 https://doi.org/10.1258/phleb.2011.011147
38. Goodyear SJ, Nyamekye IK. Radiofrequency ablation of varicose veins: Best practice techniques and evidence. Phlebology . 2015;30(2 Suppl):9–17. PMID: 26556697 https://doi.org/10.1177/0268355515592771
39. Badham GE, Dos Santos SJ, Whiteley MS. Radiofrequency-induced thermotherapy (RFiTT) in a porcine liver model and ex vivo great saphenous vein. Minim Invasive Ther Allied Technol . 2017;26(4):200–206. PMID: 28151029 https://doi.org/10.1080/13645706.2017.1282520
40. Spiliopoulos S, Theodosiadou V, Sotiriadi A, Karnabatidis D. Endovenous ablation of incompetent truncal veins and their perforators with a new radiofrequency system. Mid-term outcomes. Vascular . 2015;23(6):592–598. PMID: 25501621 https://doi.org/10.1177/1708538114564462
41. van Den Bos RR, Neumann M, De Roos KP, Nijsten T. Endovenous laser ablation-induced complications: review of the literature and new cases. Dermatol Surg . 2009;35(8);1206–1214. PMID: 19469796 https://doi.org/ 10.1111/j.1524-4725.2009.01215.x
42. Brar R, Nordon IM, Hinchliffe RJ, Loftus IM, Thompson MM. Surgical Management of Varicose Veins: Meta-analysis. Vascular . 2010;18(4):205–220. PMID: 20643030 https://doi.org/10.2310/6670.2010.00013
43. Barker T, Evison F, Benson R, Tiwari A. Risk of venous thromboembolism following surgical treatment of superficial venous incompetence. Vasa . 2017;46(6):484–489. PMID: 28841090 https://doi.org/10.1024/0301-1526/a000656
44. Pavlović MD, Schuller-Petrović S, Pichot O, Rabe E, Maurins U, Morrison N, et al. Guidelines of the First International Consensus Conference on Endovenous Thermal Ablation for Varicose Vein Disease – ETAV Consensus Meeting 2012. Phlebology . 2015;30(4):257–273. PMID: 24534341 https://doi.org/10.1177/0268355514524568
45. Parsi K, Roberts S, Kang M, Benson S, Baker L, Berman I, et al. Cyanoacrylate closure for peripheral veins: Consensus document of the Australian College of the Phlebology. Phlebology . 2020;35(3):153–157. PMID: 31368408 https://doi.org/10.1177/0268355519864755

46. Shaidakov EV, Meltsova AZh, Porembskaya OYa, Kudinova EA, Korzhevsky DE, Kirik OV, et al. Experience With Using Cyanoacrylate Glue in Endovascular Treatment of Varicose Veins. Angiology and Vascular Surgery . 2017;23(4):62–67. (In Russ.).
47. Murzina EL, Lobastov KV, Bargandzhiya AB, Laberko LA, Popov IB. Mid-Term Results of Cyanoacrylate Embolization of Saphenous Veins. Flebologiya . 2020;14(4):311–321. https://doi.org/10.17116/flebo202014041311
48. Sannikov AB, Emelianenko VM. Cyanoacrylate Glue Compositions in Phlebology. Flebologiya . 2019;13(1):36–41. (In Russ.) https://doi.org/10.17116/flebo20191301136
49. Sannikov AB, Shaydakov EV, Emelyanenko VM, Tolstikova TG. Experimental clinical study on the use of adhesive in the obliteration of varicose veins in humans. Ambulatory Surgery (Russia) . 2020;(3–4):113–123. (In Russ.) https://doi.org/10.21518/1995-1477-2020-3-4-113-123
50. Sannikov AB, Shajdakov EV, Emelynenko VM, Drozdova IV, Demidenko YA. On the Possibility of Using the Adhesive Composition "sulfacrylate" for Obliteration of Varicose Veins of the Lower Extremities. News Khirurgii. 2020;28(3):258–267. https://doi.org/10.18484/2305-0047.2020.3.258
51. Chan YC, Law Y, Cheung GC, Ting AC, Cheng SW. Cyanoacrylate glue used to treat great saphenous reflux: Measures of outcome. Phlebology . 2017;32(2):99–106. PMID: 27052039 https://doi.org/10.1177/0268355516638200
52. Witte ME, Zeebregts CJ, de Borst GJ, Reijnen MMPJ, Boersma D. Mechanochemical endovenous ablation of saphenous veins using the ClariVein: A systematic review. Phlebology . 2017;32(10):649–657. PMID: 28403687 https://doi.org/10.1177/0268355517702068
53. Morrison N, Gibson K, McEnroe S, Goldman M, King T, et al. Randomized trial comparing cyanoacrylate embolization and radiofrequency ablation for incompetent great saphenous veins (VeClose). J Vasc Surg. 2015;61(4):985–994. PMID: 25650040 https://doi.org/10.1016/j.jvs.2014.11.071
54. Siribumrungwong B, Wilasrusmee C, Orrapin S, Srikuea K, Benyakorn T, et al. Interventions for great saphenous vein reflux: network meta-analysis of randomized clinical trials. Br J Surg . 2021;108(3):244–255. PMID: 33793723 https://doi.org/10.1093/bjs/znaa101
55. Shaydakov EV, Sannikov AB, Belentsov SM. Use of glue adhesives for obliteration of major varicose veins (multicenter comparative study). Angiology and Vascular Surgery . 2022;28(1):41–50. (In Russ.) https://doi.org/10.33029/1027-6661-2022-28-1-41-49
56. Fokin AA, Nadvikov AI, Gasnikov AV, Chernousov VV, Khisamutdinov DA, Bryzgalov AO. Vacuum-assisted glue obliteration of veins. Domestic technique of cyanoacrylate vein ablation. Angiology and Vascular Surgery . 2022;28(1):51–56. (In Russ.) https://doi.org/10.33029/1027-6661-2022-28-1-51-56
57. Lishov DE, Boyko LV, Zolotukhin IA, Ilyukhin EA, Katorkin SE, Berezko MP, et al. Duplex Ultrasound of Lower Limbs Venous System. Russian Phlebology Association Expert Panel Report. Flebologiya . 2021;15(4):318–340. (In Russ.) https://doi.org/10.17116/flebo202115041318
58. Chehab M, Dixit P, Antypas E, Juncaj M, Wong O, Bischoff M. Endovenous Laser Ablation of Perforating Veins: Feasibility, Safety, and Occlusion Rate Using a 1,470-nm Laser and Bare-Tip Fiber. J Vasc Interv Radiol . 2015;26(6):871–877. PMID: 25847149 https://doi.org/10.1016/j.jvir.2015.02.014
59. Zolotukhin IA, Karalkin AV, Iarich AN, Seliverstov EI, Kirienko AI. Dissection of the perforating veins does not improve the results of phlebectomy. Flebologiya . 2012;6(3):16–19. (In Russ.).
60. Shi H, Liu X, Lu M, Lu X, Jiang M, Yin M. The Effect of Endovenous Laser Ablation of Incompetent Perforating Veins and the Great Saphenous Vein in Patients with Primary Venous Disease. Eur J Vasc Endovasc Surg . 2015;49(5):574–580. PMID: 25754773 https://doi.org/10.1016/j.ejvs.2015.01.013
61. Seren M, Dumantepe M, Fazliogullari O, Kucukaksu S. Combined treatment with endovenous laser ablation and compression therapy of incompetent perforating veins for treatment of recalcitrant venous ulcers. Phlebology . 2017;32(5):307–315. PMID: 26130052 https://doi.org/10.1177/0268355515594075
62. Obermayer A, Göstl K, Walli G, Benesch T. Chronic venous leg ulcers benefit from surgery: long-term results from 173 legs. J Vasc Surg . 2006;44(3):572–579. PMID: 16950436 https://doi.org/10.1016/j.jvs.2006.05.039
63. Pittaluga P, Rea B, Barbe R. Methode ASVAL (Ablation Selective des Varices sous Anesthesie Locale): principles et resultats preliminaires. J Malad Vascul. 2005;30(4):44. https://doi.org/10.1016/S0398-0499(05)86322-X
64. Olivencia JA. Minimally invasive vein surgery: ambulatory phlebectomy. Tech Vasc Interv Radiol. 2003;6(3):121–124. PMID: 14614696 https://doi.org/ 10.1053/s1089-2516(03)00059-3
65. Pittaluga P, Chastsnet S, Rea B, Barbe R. Midterm results of the surgical treatment of varices by phlebectomy with conservation of a refluxing saphenous vein. J Vasc Surg . 2009;50(1):107–118. PMID: 19563959 https://doi.org/10.1016/j.jvs.2008.12.067
66. Zolotukhin IA, Seliverstov EI, Zakharova EA, Kirienko AI. Isolated Phlebectomy Leads to Disappearance of Great Saphenous Vein Reflux. Flebologiya . 2016;10(1):8–18. (In Russ.) https://doi.org/10.17116/flebo20161018-16
67. Biemans M, Anke A, van den Bos RR, Hollestein LM, Birgitte MaessenVisch M, Yvonne Vergouwe, et al. The effect of single phlebectomies of a large varicose tributary on great saphenous vein reflux. J Vasc Surg Venous Lymphatic Disorder . 2014;2(2):179–187. PMID: 26993185 https://doi.org/10.1016/j.jvsv.2013.11.003
68. Nicolaides A, Kakkos S, Eklof B, Perrin M, Nelzen O, Neglen P, et al. Management of chronic venous disorders of the lower limbs. Guidelines according to scientific evidence. Int Angiol . 2014;33(2):87–208. PMID: 24780922
69. Labropoulos N, Giannoukas AD, Delis K, Mansour MA, Kang SS, Nicolaides AN, et al. Where does venous reflux start? J Vasc Surg . 1997;26(5):736–42. PMID: 9372809 https://doi.org/10.1016/s0741-5214(97)70084-3
70. Zamboni P, Cisno C, Marchetti F, Quaglio D, Mazza P, Liboni A. Reflux Elimination Without Any Ablation or Disconnection of the Saphenous Vein. A Haemodynamic Model for Venous Surgery. Eur J Vasc Endovasc Surg . 2001;21(4):361-369. PMID: 11359339
71. Mirakhmedova SA, Seliverstov EI, Zakharova EA, Efremova OI, Zolotukhin IA. 5-Year Results of ASVAL Procedure in Patients with Primary Varicose Veins. Flebologiya . 2020;14(2):107–112. https://doi.org/10.17116/flebo202014021107
72. Nicolini P, Closure Group. Treatment of primary varicose veins by endovenous obliteration with the VNUS Closure system: results of a prospective multicentre study. Eur J Vasc Endovasc Surg . 2005;29(4):433–439. PMID: 15776398 https://doi.org/10.1016/j.ejvs.2004.12.022
73. O'Donnell TF, Balk EM, Dermody M, Tangney E, Iafrati MD. Recurrence of varicose veins after endovenous ablation of the great saphenous vein in randomized trials. J Vasc Surg Venous Lymphatic Disorder . 2016;4(1):97–105. PMID: 26946904 https://doi.org/10.1016/j.jvsv.2014.11.004
74. De Maeseneer M, Pichot O, Cavezzi A, Earnshaw J, van Rij A, et al. Duplex Ultrasound Investigation of the Veins of the Lower Limbs after Treatment for Varicose Veins - UIP Consensus Document. Eur J Vasc Endovasc Surg . 2011;42(1):89–102. PMID: 21530331 https://doi.org/10.1016/j.ejvs.2011.03.013

75. van Groenendael L, Flinkenflogel L, van der Vliet JA, Roovers EA, van Sterkenburg SMM, Reijnen MMPJ. Conventional surgery and endovenous laser ablation of recurrent varicose veins of the small saphenous vein: a retrospective clinical comparison and assessment of patient satisfaction. Phlebology . 2010;25(3):151–157. PMID: 20483865 https://doi.org/10.1258/phleb.2009.009044
76. Theivacumar NS, Gough MJ. Endovenous Laser Ablation (EVLA) to Treat Recurrent Varicose Veins. Eur J Vasc Endovasc Surg . 2011;41(5):691–696. PMID: 21354832 https://doi.org/10.1016/j.ejvs.2011.01.018
77. Darvall KAL, Bate GR, Adam DJ, Silverman SH, Bradbury AW. Duplex ultrasound outcomes following ultrasound-guided foam sclerotherapy of symptomatic recurrent great saphenous varicose veins. Eur J Vasc Endovasc Surg . 2011;42(1):107–114. PMID: 21474347 https://doi.org/10.1016/j.ejvs.2011.03.010
78. Pittaluga P, Chastanet S, Locret T, Rousset O. Retrospective evaluation of the need for a redo surgery at the groin for the surgical treatment of varicose vein. J Vasc Surg. 2010;51(6):1442–1450. PMID: 20304592 https://doi.org/10.1016/j.jvs.2009.12.065
79. Perrin M, Gillet JL. Management of recurrent varices at the popliteal fossa after surgical treatment. Phlebology . 2008;23(2):64–68. PMID: 18453481 https://doi.org/10.1258/phleb.2007.007036

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