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Invasive Treatment of Lower Limb Varicose Veins - Comparison of Treatment Methods

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ABSTRACT:

Introduction and objective: Varicose veins in the lower extremities are a clinical manifestation of chronic venous disease. The condition is highly prevalent, with incidence increasing with age. Varicose veins are often accompanied by pain, and neglecting treatment can lead to complications such as superficial vein inflammation, deep vein thrombosis, and, most critically, pulmonary embolism. The primary aim of this study was to analyze and compare the efficacy and safety of available contemporary invasive methods for treating varicose veins in the lower extremities. Additionally, this paper addresses the epidemiology, etiology, and clinical presentation of chronic venous insufficiency.

Review methods: The literature review utilized databases covering sources from PubMed, Google Scholar, Web of Science and Scopus. Keywords included: 'varicose veins of the lower limbs'; 'spider veins'; 'EVLT (endovenous laser treatment of the small saphenous vein and great saphenous vein)'; 'sclerotherapy'; 'diode laser'; 'varicose vein surgeries of the lower limbs'.

Brief description of the state of knowledge: Numerous methods for treating lower limb varicose veins are available. Among all treatment options, minimally invasive procedures using laser technology, steam, or radiofrequency waves are the most common. These procedures have been successfully performed for many years, with an estimated effectiveness of approximately 90% over a five-year observation period.

Summary: Despite the high prevalence and complex pathophysiological mechanisms of varicose veins in the lower extremities, current treatment methods allow for a satisfactory therapeutic outcome in most patients.

Keywords: varicose veins of the lower limbs; spider veins; EVLT (endovenous laser treatment); sclerotherapy; diode laser; endovascular surgery

INTRODUCTION AND OBJECTIVE:

Chronic venous disease (CVD) is highly prevalent in the population and is associated with several risk factors, including female gender, obesity, arterial hypertension and smoking [1,2]. Subjective and objective symptoms of CVD are present in approximately 40% of individuals in the Polish population. [3]. The incidence increases significantly with age and is characterized by a complex and varied range of pathologies and changes, from telangiectasias, reticular veins, and lower limb varicose veins, to limb edema and, finally, leg ulcers, which are a morphological indicator of chronic venous insufficiency and can lead to severe disability [4]. In industrialized countries, lower limb varicose veins affect 20-50% of adults, increasing their prevalence with age. They occur six times more frequently in people over sixty than in those in their thirties. Women are twice as likely to develop varicose veins as men. Approximately 50% of women and 20% of men report discomfort associated with varicose veins [5]. It is estimated that the annual cost of treating varicose veins in Western countries may exceed 2% of the total healthcare budget [6,7].

Varicose veins develop due to the failure of the venous valve system, resulting in the backward flow of venous blood, known as reflux. Studies indicate that reflux can also be caused by the weakening of vein walls, which contributes to their dilation. Possible causes of wall weakening include altered collagen composition, decreased elastin content, chronic inflammation, and cytokine release [8–10].

Venous hypertension is considered a causative factor in the morphological changes leading to valve dysfunction and worsening vascular reflux. Several factors play a significant role in the development of lower limb varicose veins [2,9,11,12]:

- genetic factors: these determine a weaker connective tissue structure and lower elastic fiber content in the vessel wall, impairing the normal contraction and relaxation of veins;
- pregnancy: hormonal changes and the pressure exerted by an enlarging uterus on blood vessels can initiate the development of varicose veins. The risk increases with subsequent pregnancies;

- obesity: excess weight puts additional strain on the venous system, leading to the overload of the lower legs and feet during walking and increased blood stasis in the veins of the lower limbs;
- diet: a diet rich in dietary fiber helps fill, cleanse, and strengthen the intestines. A diet low in fiber leads to inadequate bowel movement, promoting constipation and the descent of the intestines toward the pelvis, compressing major veins and causing blood stasis in the lower limbs. High ambient temperatures exacerbate varicose veins or intensify existing symptoms, such as swelling, leg heaviness, and muscle cramps;
- age;
- female sex;
- type of work and sedentary lifestyle;
- use of oral contraceptives;
- constipation;
- food posture disorders - flat feet and high arches increase the risk of venous insufficiency;
- tall stature.

Varicose veins in the lower extremities are often accompanied by pain, and neglecting treatment can lead to complications such as superficial phlebitis, deep vein thrombosis, and, most dangerously, pulmonary embolism. Untreated varicose veins cause hard-to-heal wounds, such as leg ulcers [13–15].

This study aims to analyze and compare current knowledge on the efficacy and safety of contemporary invasive methods for treating varicose veins in the lower extremities. The selection of an appropriate treatment method depends on clinical presentation and imaging results, as discussed in this paper.

REVIEW METHODS:

The literature review utilized databases covering sources from PubMed, Google Scholar, Web of Science and Scopus using the search terms encompassing the following keywords: ‘varicose veins of the lower limbs’; ‘spider veins’; ‘EVLT (endovenous laser treatment of the small saphenous vein and great saphenous vein)’; ‘sclerotherapy’; ‘diode laser’; ‘varicose vein surgeries of the lower limbs’. The selected literature included research

articles, review papers, meta-analyses, and randomized controlled trials. A total of 44 publications were chosen, with an emphasis on the most recent findings on the topic. Publications in languages other than English or Polish were excluded.

DISCUSSION:

Chronic Venous Insufficiency - Clinical Presentation:

Varicose veins of the lower limbs most commonly affect the great saphenous veins, the small saphenous veins, and their superficial tributaries. They can be divided into: telangiectasias, reticular veins, and varicose veins of the main venous trunks [16]. The CEAP classification is a globally recognized standard for describing patients with chronic venous disorders. It enables precise diagnosis of chronic venous disorders, has standardized diagnostics, and its worldwide use has ensured a universal and understood description of venous disorders. The acronym CEAP stands for: C - clinical signs, E - etiology (congenital, primary, acquired), A - anatomical distribution (superficial, perforating, or deep veins),
P - pathophysiological condition (obstruction or reflux) [17,18]. According to its principles, the following clinical categories are distinguished:

- C0 – no visible or palpable signs of venous disease;
- C1 – telangiectasias and/or reticular veins;
- C2 – varicose veins;
- C3 – edema;
- C4 – skin changes attributed to venous disease;
- C4a – pigmentation, venous eczema;
- C4b – lipodermatosclerosis, atrophie blanche;
- C5 – skin changes as above and the presence of healed ulceration;
- C6 – skin changes as above and active ulceration.

In most cases (60-80%), varicose veins of the lower limbs indicate insufficiency of the superficial venous system, while only 10-20% of patients develop them due to insufficiency of the deep venous system. In the initial phase, usually only cosmetic changes are visible in the form of telangiectasias (dilations of intradermal venules up to 1 mm) and reticular veins (intradermal dilations of 1-4 mm), which herald the early stage of venous insufficiency. These changes can occur singly or form clusters in the shape of a "spreading

bush". They can be located in various areas, such as on the lateral surface of the thigh, in the popliteal fossa, or around the medial ankle, where their radiating arrangement is referred to as corona phlebectatica [19]. Reticular veins have a longer course than telangiectasias. They are most commonly found on the lateral side of the thigh or in the popliteal area. They appear as blue, narrow lines that primarily branch at the top into smaller ones, leading to telangiectasias. Similar to telangiectasias, they rarely become inflamed and therefore have limited clinical significance. Clinically significant varicose veins of the lower limbs most commonly (90%) form from the tributaries or trunks of the great saphenous vein, and to a lesser extent (5%) from the small saphenous vein. In cases of dilation of the great saphenous vein at the confluence with the common femoral vein in the groin, a soft, painless lump may appear. In individuals with well-developed subcutaneous tissue, this lump is most often palpable in the lower thigh and calf. In the early stage, insufficiency of the small saphenous vein is indicated by the presence of telangiectasias or reticular veins in the popliteal fossa and/or on the posterior surface of the thigh. Insufficiency of the vessel along its entire length causes dilation of the vein in the Achilles tendon or lateral ankle area [16]. Varicose and insufficient perforators can also become dilated, appearing as soft protrusions that are especially visible when standing. They are most commonly found on the medial surface of the lower leg, on the thigh, and less frequently on the posterior surface of the lower leg. Sometimes, a dilated vein is visible above the perforator. Insufficiency of the perforators is often associated with insufficiency of the great or small saphenous vein. Edema occurs in about 50% of patients with chronic venous insufficiency (CVI). It is a clinical manifestation of increased extracellular fluid volume. Edema appears as a result of insufficiency of the superficial veins, as well as the deep veins, in which case its intensity is significantly greater. Nutritional changes in the skin are, alongside edema and developing varicose veins, the earliest symptoms of venous hypertension. The characteristic location of their occurrence is the area above the ankles, known as the gaiter area, most commonly on the medial surface of the lower leg [20,21]. The clinical presentation of these changes is diverse, ranging from skin discoloration and inflammatory states to hard-to-heal ulcers. The first symptom of skin changes is increased pigmentation, known as hemosiderosis. Hemosiderin deposits, which are the product of red blood cell breakdown, give the skin a characteristic reddish-brown color. These changes initially appear as small, light brown spots, which over time merge into uniform areas above the ankles. As the disease progresses, the coloration becomes more intense and often covers the entire lower leg. Changes in skin thickness and subcutaneous

tissue accompany the discoloration. Fat tissue atrophies and is replaced by fibrous tissue. The skin becomes thin, inelastic, hard, and dry. In about 1% of patients, an ulcer appears on the affected skin. The cause of its formation can be the insufficiency of superficial, deep, and perforating veins or two or three simultaneously. Similar to skin changes, the ulcer is most often located around the medial ankle, i.e., the area most exposed to the negative effects of venous hypertension [22,23]. An ulcer can result from, for example, trauma, skin irritation, or scratching by the patient due to itching. In terms of healing dynamics, venous ulcers can be divided into hard-to-heal ulcers, requiring treatment for months and years, and ulcers with a clear tendency to heal. According to available data, 20% of ulcers do not heal within two years. After 5 years, the rate is lower but still affects about 8% of patients treated for venous ulcers. Venous ulcers tend to recur. Western studies on epidemiology report that recurrences occur in 26% to 70% of patients. More than half of the patients suffer from repeatedly recurring wounds. Literature indicates that 26% of ulcers recur within the first 12 months after the end of therapy. With the use of effective preventive strategies, the frequency of recurrences decreases and occurs in 16-25% of patients. In the course of chronic venous insufficiency and ulceration, in addition to the aforementioned symptoms, complications such as inflammation and thrombophlebitis of the superficial or deep veins or hemorrhage from a varicose vein may occur [24–29].

Diagnosis:

Duplex ultrasound is the first-choice examination for patients with suspected chronic venous disease (CVD), and its results are also used in treatment planning [I/B]. It allows for the assessment of deep and superficial veins as well as valvular insufficiency of the main trunks of the superficial veins (great and small saphenous veins). In case of doubt, the examination should be extended to assess the iliac veins, keeping in mind that this requires appropriate experience from the examiner. If surgical treatment is being considered, additional venography using computed tomography (CT) or magnetic resonance imaging (MRI) [I/C] is performed to better visualize the pelvic veins. If results are inconclusive, intravascular ultrasound or venography [IIb/B] can be considered, although the former is very difficult to access and the latter is almost no longer performed. Ultrasound does not allow for the assessment of small veins (e.g. intradermal veins) or the overall venous efficiency of the entire lower limb. Many individuals exhibit evident signs of CVD (e.g., telangiectasias, reticular veins, or edema), yet the ultrasound results of the main venous trunks are normal. To

comprehensively assess the venous efficiency of the limb, plethysmographic examination is used; however, in clinical practice, it is almost as inaccessible as the aforementioned tests [30–33].

Indications for Surgical Treatment:

Due to the effectiveness of minimally invasive techniques, the range of indications for surgical treatment is continuously expanding. According to ESVS guidelines, individuals with symptomatic varicose veins of the lower limbs should qualify for treatment - C2S according to CEAP [I/B], those with edema (after excluding other non-venous causes) - C3 according to CEAP [IIa/C], and those with skin changes secondary to CVD - C4-6 according to CEAP [I/C]. The guidelines clearly emphasize that endovascular procedures (with possible miniphlebectomy) should be performed on an outpatient basis [I/C]. It should be noted that none of the minimally invasive procedures are reimbursed by the National Health Fund in Poland [30–32].

Surgical methods – description, effectiveness, complications:

Surgical treatment is the oldest method for therapy of lower limb varicose veins. It was invented by William Wayne Babcock in 1905. Currently, surgical treatment of chronic venous insufficiency (CVI) has limited significance. The main methods include high ligation stripping and miniphlebectomy [30–32,34]. The stripping procedure involves removing the incompetent vein (typically the great saphenous vein) using a special probe. The great saphenous vein and its tributaries are dissected, and its end is tied off flush with the femoral vein, leaving as minimal a stump as possible; this part of the procedure is called crossectomy. Subsequent incisions are made in the upper part of the calf, along the path of the great saphenous vein. The stripper is secured through an incision below the knee in the vein and passed towards a groin incision, then the great saphenous vein is removed from the thigh area. In currently used procedures, only the thigh segment is removed, leaving the vein in the calf, as this is associated with a lower incidence of neurological complications and the potential for its future use in cardiac surgery. It is also possible to perform just the ligation of the great

saphenous vein, but this is associated with a much higher rate of recurrence. There are two alternatives to stripping: invaginated stripping and cryostripping. Invaginated stripping involves inserting the free end of the vein mounted on a stripper into its interior, followed by removal of the vessel. Cryostripping involves inserting a probe cooled with liquid nitrogen through an incision below the knee. The vein is then frozen, its distal segment ruptures, and the remaining part is removed with the probe [35]. No difference in postoperative pain and loss of sensation has been shown between stripping and cryostripping within 6 months after the procedure [30,31].

Miniphlebectomy involves the removal of incompetent venous tributaries using special hooks through small skin incisions. This procedure can also be performed in outpatient settings under local anesthesia. Small incisions are made along the course of varicose veins, then the veins are pulled through the incisions using Müller hooks or Graefe forceps. Finally, they are detached using a clamp. The wounds are so small that they do not require stitches, resulting in better cosmetic outcomes. A modification of the miniphlebectomy method is illuminated, mechanically assisted phlebectomy, known as TIPP (Translumination Powered Phlebectomy) or TriVex. These methods involve mechanical removal of varicose veins. A transluminator (a strong light source) is inserted into the subcutaneous tissue through a small incision, allowing visualization of varicose veins and providing tumescent anesthesia. The varicose veins are fragmented and suctioned out with a special tip. This technique enables the removal of large clusters of varicose veins in a relatively short time (approximately 20 minutes). Complications after the procedure include bruising, significant pain, swelling, paresthesia, hypersensitivity, formation of skin indentations due to tissue suctioning, and discoloration. A comparison between manual and powered phlebectomy revealed that, despite fewer incisions in powered phlebectomy, patients experienced higher rates of varicose vein recurrence, along with more extensive bruising, greater pain, and a reduced post-operative quality of life compared to those who underwent traditional phlebectomy. Currently, minimally invasive methods play a primary role in the treatment of chronic venous insufficiency (CVI), with two rapidly evolving groups of procedures: thermal and non-thermal. Thermal methods primarily include endovenous laser ablation (EVLA) and radiofrequency ablation (RFA). Both techniques involve inserting devices that emit laser radiation or radiofrequency waves into the vein lumen, which heat the vessel wall, leading to its closure. These procedures require local anesthesia, most commonly

tumescent anesthesia - a type of local anesthesia in which large volumes of specially prepared diluted anesthetic drugs are used to numb the area. The most common complication of endovenous thermal ablation is bruising, occurring in 75% of patients. Serious complications include the potential formation of a thrombus at the junction of the deep and superficial venous systems, as well as nerve damage, numbness, or hypersensitivity along the treated vein, which typically resolves within a few weeks. These methods carry a low risk of infection, making them suitable for patients with active ulcers. Neovascularization rates are estimated at approximately 1-1.5%. Compression therapy is recommended after thermal endovenous ablations to shorten recovery time and reduce pain [30,31,36,37].

Steam vein sclerosis (SVS) is the newest thermal method, similar to RFA and EVLT. Steam heated to 120°C is delivered into the vein through a catheter. This method allows for controlled parameters and a specific amount of energy. Its advantage lies in the use of a thin and flexible catheter that can be applied to small perforators. Further studies are needed to establish its long-term effectiveness [30,31].

Non-thermal methods include sclerotherapy (performed under ultrasound guidance, known as echo sclerotherapy) and its variants, such as mechanical-chemical ablation (MOCA) and less commonly used cyanoacrylate glue ablation in Poland. Sclerotherapy involves injecting an obliterating agent (in the form of foam or liquid) into the vein lumen, which irritates the vein wall, induces inflammation, and leads to fibrosis and closure of the vein.

Two methods of sclerotherapy are distinguished: conventional sclerotherapy and foam sclerotherapy [30,31,38].

Conventional sclerotherapy involves injecting a sclerosing agent directly into the lumen of the varicose vein for obliteration. Currently, the preferred treatment method is ultrasound-guided foam sclerotherapy (UGFS). This technique involves injecting a sclerosing agent mixed with gas into the vein. Commonly used agents include sodium tetradecyl sulfate, polidocanol, n-butyl cyanoacrylate, and hypertonic solutions. The agent is mixed with gas in ratios of 1:4 or 1:5 to ensure optimal viscosity and stability of the foam. The injected foam displaces blood within the vessel, allowing precise control of the treatment area [39,40]. The use of ultrasound enables access to deep veins and larger varicose veins up to 10mm in diameter. This advanced method extends beyond treating spider veins, telangiectasias, or reticular veins and can be performed on an outpatient basis. Patients may receive injections while standing or lying down. For injections into the great saphenous or small saphenous veins, the entry point should be at least 10 cm away from the groin or knee junction to avoid

deep vein thrombosis. The limb should be elevated during the procedure to prevent foam displacement. Immediate application of compression bandages is not recommended. Compression stockings should be worn 10 minutes after the procedure to aid in recovery, although the efficacy of post-procedural compression therapy remains inconclusive. Despite its benefits, such as minimal discomfort, a low incidence of hematoma, and the absence of burn risks, foam sclerotherapy can lead to temporary complications, including skin discoloration and neurological issues such as visual disturbances or migraine-like headaches. Skin discoloration is the most common complication, typically resolving over time. Cases of pulmonary embolism have been reported but are rare. Contraindications to sclerotherapy include symptomatic persistent foramen ovale, severe thrombophilia, and pregnancy [30,31,39,40]. Varying volumes of sclerosing agents are recommended depending on the size of the treated vein, with a maximum single dose of 10 ml [41]. A study demonstrated that ultrasound-guided foam sclerotherapy was superior to liquid sclerotherapy in terms of closing the great saphenous vein and reducing varicose vein recurrence after one year. However, the study's limitations included a small sample size and a short observation period. Compression stockings are typically prescribed post-sclerotherapy and are individually fitted to the patient. Additionally, transcatheter laser therapy is used for treating telangiectasias and reticular veins. Minimally invasive procedures are performed on an outpatient basis, are effective (with closure rates comparable to surgery in short- and long-term observations), and are well-tolerated by patients [42]. The European Society for Vascular Surgery (ESVS) provides key recommendations for selecting an invasive method based on observed venous pathology. It is essential to make treatment decisions collaboratively with patients, taking into account anatomical considerations (vessel caliber, skin changes) and the expertise of the treatment center where the procedure will be performed (Table 1).

Table 1. Recommended invasive methods in the treatment of chronic venous disease of the lower limbs in specific clinical situations (EVLA - Endovenous Laser Ablation HLS - High Ligation and Stripping of the vein MOCA - Mechanochemical Ablation RFA - Radiofrequency Ablation UGFS - Ultrasound Guided Foam Sclerotherapy) [30–32].

Clinical situation	Recommended invasive treatment method
incompetence of the great saphenous vein	- EVLA or RFA (instead of HLS and UGFS) [I/A] - If EVLA or RFA cannot be applied, consider stripping [IIa/A] - If a non-thermal method not requiring tumescent anesthesia is necessary, prefer closure using glue

	[IIa/A] or MOCA [IIb/A] - If the diameter of the great saphenous vein is <6 mm, consider UGFS [IIb/B]
additional anterior accessory saphenous vein	EVLA or RFA [IIa/C], consider UGFS [IIb/C]
incompetence of the small saphenous vein	EVLA or RFA (instead of surgical treatment and UGFS) [I/A], consider non-thermal methods [IIb/B]
incompetence of main venous trunks	Miniflebectomy or UGFS or a combination of both methods [I/B]
reticular veins (diameter 1-3 mm)	Sclerotherapy is the method of choice [I/A]
telangiectasia	Consider sclerotherapy [IIa/A] and transcutaneous laser therapy [IIa/B]
incompetent perforators	Consider intravascular methods, incision, or surgical ligation [IIa/C]

Comparison of effectiveness of available invasive treatments for lower limb varicose veins:

In a 5-year follow-up study comparing endovenous laser ablation (EVLA) and high ligation with stripping to ultrasound-guided foam sclerotherapy (UGFS), better outcomes were achieved with EVLA and stripping. The incidence of reflux recurrence in the femoral-popliteal junction after 5 years was higher with UGFS and EVLA compared to high ligation with stripping [43]. Endovenous laser therapy and radiofrequency ablation have similar safety and effectiveness profiles [44]. Thermal interventions were associated with a poorer overall quality of life compared to non-thermal interventions, but had a lower risk of recurrent incompetence compared to UGFS. Foam sclerotherapy shows a higher complication rate than liquid sclerotherapy but has a more clinically stable effect [38]. Among all available varicose vein treatments, minimally invasive procedures utilizing laser, steam, or radiofrequency technology are undoubtedly the most common. These technologies belong to the category of thermal methods, which involve damaging vessel walls using heat. These procedures have been successfully performed for many years, with an estimated effectiveness rate of around 90% in a five-year observation period. The most effective treatment method for varicose veins is one that is individually tailored to the patient's health needs based on detailed diagnostic studies. Long-term clinical experience suggests that a combination of technologies or techniques often yields the best therapeutic outcomes. However, proper selection of treatment based on the extent of the problem requires medical consultation, during which Doppler ultrasound examination is conducted. Precise lower limb diagnostics using ultrasound allow for the assessment of blood flow through vessels, thereby verifying the competence of veins and arteries [30,31].

SUMMARY:

Chronic venous disease (CVD) is one of the most common vascular disorders, with a significant impact on patient health and quality of life. The advent of new technologies has transformed the treatment of varicose veins. Duplex ultrasound, in particular, has improved all facets of varicose vein therapy, from accurate diagnosis to effective treatment. Although traditional surgical methods remain in use, minimally invasive techniques are increasingly preferred, providing patients with enhanced comfort during and after procedures and enabling a quicker return to daily activities. A key advantage of minimally invasive methods is their favorable cosmetic outcomes, an important factor for many patients when selecting the optimal treatment approach.

DISCLOSURES:

Authors' contribution:

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