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Treatment Methods for Varicose Veins of the Lower Limbs

Marcin Wąs

District Medical Center in Grójec, Piotra Skargi 10 street, 05-600 Grójec, Poland

mos1@vp.pl

https://orcid.org/0009-0004-8645-0121

Aleksandra Latała

District Medical Center in Grójec Piotra Skargi 10 street, 05-600 Grójec, Poland

aleksandra.latala10@gmail.com

https://orcid.org/0009-0007-1701-2728

Natalia Zozula

District Medical Center in Grójec, Piotra Skargi 10 street, 05-600 Grójec, Poland

nataliazozula0@gmail.com

https://orcid.org/0009-0009-9741-5061

Aleksandra Rykucka
Rear Admiral Professor Wiesław Łasiński 7th Military Navy Hospital with Outpatient Clinic named after in Gdańsk, Polanki 117 street, 80-305 Gdańsk, Poland
aleksandra.rykucka@wp.pl
https://orcid.org/0009-0003-0171-8647

Justyna Kiełbasa
Independent Public Healthcare Complex in Pruszków, 2/4 Armii Krajowej Avenue, 05-800 Pruszków, Poland
justynakielbasa1b@gmail.com
https://orcid.org/0009-0002-0616-7402

Agata Kowalczyk
Mazovian Specialized Hospital in Ostrołęka of Józef Psarski, Jana Pawła II 120A, 07-410 Ostrołęka, Poland
agata.kowalczyk95@gmail.com
https://orcid.org/0009-0007-9497-0970

Katarzyna Bil
Independent Public Specialist Western Hospital named after St John Paul II,
Daleka 11, 05-825 Grodzisk Mazowiecki, Poland
katarzynabil2503@gmail.com
https://orcid.org/0009-0003-6518-1711

Iga Ślesicka
Mazovian Specialized Hospital in Ostrołęka of Józef Psarski, Jana Pawła II 120A, 07-410 Ostrołęka, Poland
igaslesicka@gmail.com
https://orcid.org/0000-0001-7282-4875

Zuzanna Tomczewska
Provincial Specialist Hospital named after Blessed Father Jerzy Popiełuszko in Włocławek, Wieniecka 49, 87-800 Włocławek, Poland

ztomczewska@gmail.com
https://orcid.org/0000-0002-4327-3311

Magda Przestrzelska
Faculty of Medicine Collegium Medicum Uniwersytet Kardynała Stefana Wyszyńskiego w Warszawie, Wóycickiego 1/3, 01-938 Warszawa, Poland
magda.przestrzelska123@gmail.com
https://orcid.org/0009-0009-8688-7047

Abstract:

Introduction and Purpose: Varicose veins in the lower limbs are common, particularly among those with prolonged standing occupations, contributing to chronic venous insufficiency (CVI). CVI affects about 60% of adults, with varicose veins present in 25–33% of women and 10–20% of men, increasing with age. Understanding and addressing this condition is crucial as it impacts daily life and raises the risk of thrombosis. Effective treatments are essential to alleviate these health issues.

State of Knowledge: Varicose veins result from a mix of genetic, hemodynamic, and vein wall factors. Family history plays a significant role, increasing susceptibility. Hemodynamic issues include malfunctioning venous valves and elevated venous pressure. Vein wall changes and thrombotic activity also contribute. Symptoms range from cosmetic concerns to pain and complications like venous ulcers. Understanding these factors is key for effective management.

Conclusions: Surgical treatments like high ligation and stripping are standard but have drawbacks such as scarring and long recovery. Valvuloplasty addresses deep venous valve issues but is limited. Minimally invasive options, such as endovenous laser therapy and sclerotherapy, offer promising alternatives but with some recurrence risk. Compression therapies, including elastic stockings and pneumatic compression, aid recovery and symptom relief. Elastic bandage therapy is effective but requires precise application to avoid complications. Each method has pros and cons, underscoring the need for tailored treatment approaches.

Key words: Varicose veins, Chronic venous insufficiency, Hemodynamic abnormalities, Genetic predisposition, Minimally invasive therapies, Compression therapy

1. Introduction and purpose

Currently, varicose veins of the lower extremities rank among the most common conditions affecting individuals engaged in occupations requiring prolonged standing. The nature of such work significantly influences the pathogenic mechanisms of lower extremity varicose veins.

Chronic venous insufficiency (CVI) is a prevalent condition. The estimated prevalence of this condition in the adult population is around 60%, with significantly higher rates observed in highly developed countries. Obtaining precise epidemiological data on chronic venous insufficiency is challenging due to the need to consider individual disease stages separately. In Western European countries, varicose veins affect 25–33% of women and 10–20% of men, with prevalence increasing with age – from 3% in men and 20% in women in the third decade of life to 40% and 50%, respectively, by the age of 70. Current data suggest that it may affect up to one-third of adults [1]. These statistics underscore the importance of understanding and preventing this condition. Varicose veins, marked by enlarged and convoluted superficial vessels measuring a minimum of 3 mm in width, stand as a prevalent issue within the continuum of chronic venous insufficiency affecting the lower extremities. Beyond mere aesthetic considerations, these venous anomalies significantly disrupt patients' daily lives. Notably, their existence heralds an augmented susceptibility to superficial vein thrombosis and subsequent venous thromboembolism [2].

Considering the fact that this condition affects a significant portion of the global population, it is important to pay attention to the available treatment methods for such disorders. Furthermore, the development of varicose veins in the lower limbs due to chronic venous insufficiency leads to numerous, often very serious health complications.

1. The state of knowledge

Anatomy

The blood in the veins flows back to the heart's right side via both the superficial and deep venous systems. The superficial system includes major veins like the great saphenous vein (GSV) and the small saphenous vein (SSV), along with their smaller branches. The great saphenous vein (GSV) originates proximally from the medial extremity of the dorsal venous arch, coursing anteriorly to the medial malleolus before ascending along the medial aspect of the calf and thigh to converge with the common femoral vein at the saphenofemoral junction (SFJ) [3]. Conversely, the small saphenous vein (SSV) emanates distally from the lateral end of the dorsal venous arch, traverses posteriorly to the lateral malleolus, and ascends along the posterior calf, often intercalating between the gastrocnemius heads, to ultimately join the popliteal vein at the sapheno-popliteal junction (SPJ). The presence of the SPJ may be variable, wherein its absence prompts the SSV to continue its trajectory along the postero-medial thigh (Giacomini vein), frequently establishing an anastomotic connection with the GSV. These venous systems are intricately interconnected through a labyrinthine network of tributaries. In the deep venous system, veins are typically paired with accompanying arteries. Furthermore, the superficial and deep systems communicate via numerous non-junctional perforators, augmenting their anatomical and physiological interdependence in both pathological and physiological states [4].

Pathophysiology

Multiple attempts have been made to identify the factors responsible for the development of varicose veins in the lower limbs [5]. The causative relationship between localized vein wall dysfunction and valvular incompetence remains ambiguous. There exists a complex interplay of environmental, genetic, histologic, and hemodynamic elements, as evidenced in literature. It is probable that the pathogenesis of varicose veins arises from a multifactorial imbalance involving more than one of these factors [6].

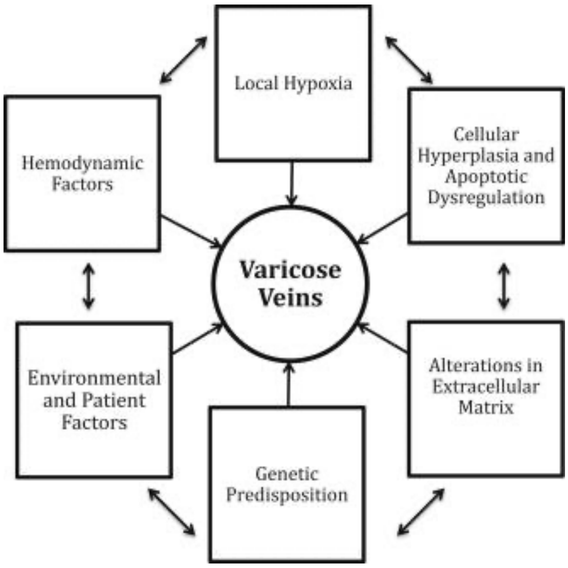

Figure 1 - Pathophysiology of varicose veins [5].

Hemodynamic factors

The circulation within the venous system relies on intact valves and muscular contractions to facilitate the upward movement of blood towards the heart, counteracting the pull of gravity. In a typical physiological state, blood flows from the superficial veins to the deeper veins and ultimately towards the central veins in a direction opposite to gravity. Valves within the superficial, deep, and perforating veins play a crucial role by ensuring the one-way flow of blood, preventing retrograde flow. The dilation of varicose veins may stem from the malfunction of these valves in the lower limbs, allowing the reversal of the pressure gradient from the deep venous system to the superficial veins via the saphenofemoral junction (SFJ) and perforating collaterals [7].

To support the hypothesis concerning hemodynamic factors, it is worth noting that anatomical and ultrasonographic studies have demonstrated valvular dysfunction in individuals afflicted with this condition.
Incompetence typically manifests most frequently in the distal branches, with the below-knee segment of the great saphenous vein serving as the primary site of occurrence [8].
Another factor influencing the progression of lower extremity varicose veins is increased pressure within the venous system. In Engelhorn's study, there was no definitive evidence

indicating the involvement of saphenous vein reflux in the pathogenesis of the aforementioned condition [5].

Research conducted on a cohort comprising both obese individuals and those within normal weight parameters unequivocally demonstrated that obesity is among the predisposing factors for venous outflow disturbances in the lower extremities [9].

Hemodynamic influences alone do not comprehensively elucidate the origins of varicose veins. Genetic predisposition significantly contributes, with a primary determinant being a familial history of the condition. Evidence suggests that individuals with a first-degree relative affected by varicose veins face heightened susceptibility. Moreover, observations have revealed instances of vein wall dilation and varicosities occurring even in regions below valves that exhibit full competency, underscoring the multifaceted nature of varicose vein development [10].

Vein wall factors

There is also a hypothesis regarding the influence of venous wall factors on the development of lower extremity varicose veins. Numerous studies have been conducted based on histopathological findings, all concurring on the involvement of these factors in the pathogenesis of the disease. The venous walls of varicose veins exhibit distinct phenotypic alterations.

Intimal and smooth muscle cell hyperplasia frequently occurs during the progression of varicose veins. This condition entails the abnormal dilation of vessels, consistently displaying enlargement beyond the typical vein diameter. Notably, varicose vein pathology is distinguished by the presence of skip lesions, which denote segments of unaffected vein interspersed among areas afflicted by varicosities [11].

Changes in the typical balance and operation of extracellular matrix (ECM) constituents and smooth muscle cells might contribute to varicosity development. Varicose veins could possess inherent deficiencies in elastic recoil, diminishing their ability to propel blood forward, resulting in blood accumulation and impaired valve cusp alignment. Studies have reported conflicting results regarding collagen levels, with some indicating increases while others observe decreases. A similar inconsistency exists for elastin levels. This variability may stem from skip lesions, making exact vein section comparisons challenging across studies. Disorganization of the ECM concerning smooth muscle fibers likely plays a more crucial role than the overall collagen and elastin content. Several studies have demonstrated collagen fiber disarray in varicose veins, which inappropriately infiltrate and mingle with smooth muscle layers. This disarray affects smooth muscle contractility, despite normal smooth muscle cell counts relative to vessel size [11,12,13]. The available data indicates a potential linkage between the HIF pathway and various pathophysiological alterations within the vascular wall of varicose veins (VV). Furthermore, hypoxia emerges as a contributory element to the pathogenesis of VV [14].

Another aspect suggesting the involvement of vein wall factors is the increased concentrations of D-dimer, a breakdown product of fibrin, detected at localized sites within varicosities compared to blood specimens drawn from the brachial vein of the same individual. This observation has led to speculation about heightened thrombotic activity and accelerated thrombus degradation within the stagnant, oxygen-deprived environment typical of varicose veins. These phenomena are believed to precede endothelial activation and the subsequent infiltration of inflammatory cells [15].

These factors render the pathogenesis of lower extremity varicose veins multifactorial, and it is not entirely clear which of these mechanisms is responsible for its induction. Given the varied environmental, genetic, histological, and hemodynamic factors delineated in the literature, it is conceivable that the pathogenesis of varicose veins emanates from a dysregulation across multiple of these variables [6].

Factors contributing to the development of chronic venous disease (CVD) include:
Genetic predisposition: The risk of CVD is approximately 40% in individuals with one affected parent and rises to 90% if both parents are affected.
age, female gender, occupational factors and sedentary lifestyle,
use of oral contraceptives, pregnancy, particularly with compression of pelvic vessels by the fetus, obesity, constipation, foot static disorders such as flat feet and high-arched feet, which increase the risk of venous insufficiency,
tall stature [16].

Symptoms

Patients with varicose veins may be asymptomatic aside from the enlarged vessel itself, but many of them experience discomfort or pain in the vein, sensations like aching, pressure, burning, itching, or tingling in the legs, and leg swelling. These symptoms typically worsen at the end of the day, following prolonged sitting or standing, and usually improve after initially getting out of bed [16][17].

In clinical practice, the CEAP classification system is commonly utilized. It encompasses a range of symptoms that may accompany the aforementioned condition, with detailed specifications regarding etiology, anatomical localization, and pathophysiological cause.

Clinical Classification		Etiologic Classification		Anatomic Classification		Pathophysiologic Classification (Basic CEAP [1])	
C0	No visible or palpable signs of venous disease	Ec	Congenital	As	Superficial veins	Pr	Reflux
C0s	C0 with minor symptoms	Ep	Primary	Ap	Perforator veins	Po	Obstruction
C1	Telangiectasia or reticular veins	Es	Secondary (postthrombotic)	Ad	Deep veins	Pr,o	Reflux and obstruction
C2	Varicose veins	En	No venous cause identified	An	No venous location identified	Pn	No venous pathophysiology identifiable
C3	Edema						
C4a	Pigmentation and/or eczema						
C4b	Lipodermatosclerosis and/or atrophie blanche						
C5	Healed venous ulcer						
C6	Active venous ulcer						
S	Symptomatic, including ache, pain, tightness, skin irritation, heaviness, and muscle cramps, and other complaints attributable to venous dysfunction						
A	Asymptomatic						

Figure 2 - Clinical, Etiologic, Anatomic, and Pathophysiologic classifications of CVD [18].

Subjective symptoms include feeling of leg heaviness, diminishing notably after rest, particularly with raised extremities, calves experiencing cramp-like pain, worsening during nighttime or while in a standing or sitting posture, and in warm conditions, with a sense of calf tightness, pain felt along the vein's pathway, tingling sensations, restlessness in the legs, itching of the skin. Among the objective symptoms are visible, tortuous veins with a bluish hue beneath the skin (initially presenting as telangiectasias), edema, initially reversible and diminishing after rest, eventually becoming persistent, rust-brown skin discoloration, especially on the medial aspects of the lower legs, areas of white atrophy covered by thin, sensitive epidermis, lipodermatosclerosis, characterized by hardening of the skin and underlying fat tissue, typically affecting the distal third of the lower leg, ulceration of the lower leg, typically in the distal third of the shin on the medial aspect, in advanced cases may involve the entire circumference of the limb, varicose eczema (eczema venostaticum) — pruritic, dry, or weeping lesions within affected tissues, resulting from stasis dermatitis [16][17].

Treatment Methods

Surgical intervention

Surgical intervention serves as the primary approach for individuals with varicose veins in their lower limbs. Common surgical procedures include high ligation and stripping, as well as valvuloplasty. Particularly, high ligation and stripping stand out as the traditional surgical methods, forming the basis for various modified techniques. Due to its effectiveness and reduced recurrence rates, it remains widely employed in clinical practice. Valvuloplasty becomes necessary in cases of deep venous valve insufficiency.

The mentioned surgical intervention cannot be performed in cases of: arterial insufficiency of the lower extremities, deep vein thrombosis, bleeding disorders, history of deep vein thrombosis, acute infectious disease, pregnancy, and severe obesity (BMI > 29) [19].

High ligation and stripping

During the procedure of high ligation and stripping, either general or spinal anesthesia is administered. The patient is positioned supine, and a 6 cm incision is made along the femoral skin crease, aligning the lateral end with the femoral pulse. Following exposure of the saphenofemoral junction, all accompanying branches are dissected and secured. The stripper is then gently guided downward within the vein, ensuring the removal of any larger protruding segments. Subsequently, the upper portion of the vein is tied off using a dual ligature, and the incision at the femoral site is closed. High ligation and stripping represents an extensive remedy, ensuring that varicose veins do not reoccur following the removal of the affected vein. The procedure offers notable advantages: it minimizes the risk of fibrosis in the surrounding tissues and eliminates the possibility of damaging adjacent structures, notably the saphenous nerve. Moreover, the technique effectively mitigates most complications associated with vein stripping operations [20].

Despite the considerable success rate, this treatment approach is accompanied by several drawbacks, including multiple incisions, significant trauma, high expenses, and similar factors.

Moreover, undergoing surgery entails risks associated with general anesthesia and entails a prolonged recovery period. Furthermore, high ligation and stripping procedures may result in permanent scarring that impacts the aesthetic appearance of the leg. Given these significant disadvantages, the surgical option is unlikely to be favored. Additionally, post-surgery, patients will be advised to wear compression stockings to enhance the effectiveness of the treatment.

Valvuloplasty

Valvuloplasty is frequently utilized in clinical practice as a method for addressing insufficiency in the valve of the great saphenous vein, a primary cause of reflux leading to various clinical symptoms and signs associated with varicose veins in the lower extremities. Addressing reflux is crucial for successful treatment. High ligation and stripping, due to its drawbacks such as high postoperative recurrence and potential discomfort for patients, may not be the most effective option. Valvuloplasty involves suturing to reshape the fold of the great saphenous vein, creating a funnel-like structure, and offers advantages including reduced incisions, simplicity of the procedure, and shorter recovery times. Nonetheless, drawbacks such as the need for hospitalization and potential complications persist [21].

Minimally invasive therapy

Increasingly, minimally invasive treatment methods are being favored for addressing varicose veins in the lower extremities, with a rising acknowledgment of their efficacy, safety, aesthetic advantages, and cost-effectiveness. Presently, among the array of options available in clinical practice, sclerotherapy and intracavitary laser therapy stand out as the most commonly utilized techniques for managing this condition.

Intracavity laser therapy

Intracavitary laser therapy involves the application of laser energy to induce high levels of heat, aiming to inflict controlled damage to the vascular wall of the affected vein. This process stimulates fibrotic repair, contraction, and subsequent closure of the venous wall. Simultaneously, the heat generated can induce a hypercoagulable state within the blood, leading to thrombosis throughout the venous structure, ultimately resulting in fibrosis-induced closure.

Furthermore, laser-induced heating causes destruction of the endothelium within the great saphenous vein, facilitating closure through external pressure application. This approach obviates the necessity for complete stripping of the main trunk of the great saphenous vein, thereby minimizing procedural trauma. With its potential to address a broader spectrum of clinical requirements, intracavitary laser therapy emerges as a promising modality in the treatment of varicose veins [22].

Endovenous thermal ablation therapy has become the preferred method for addressing primary incompetence of saphenous veins, supplanting high ligation and stripping in many cases. This transition stems from its notable effectiveness, decreased risk of complications, accelerated recovery timeframe, and the minimal discomfort experienced by patients in the postoperative phase [23].

In contrast to sclerosing agent injection, intracavity laser therapy presents a superior alternative for addressing occlusion in the large saphenous vein, offering a diminished likelihood of recurrence. However, it may not be as efficacious in managing varicose veins of the lower extremities, particularly in cases involving curved protrusions of venous groups or severely distorted variceal veins. Despite its advantages, the recurrence rate associated with laser therapy remains higher than that of surgical interventions [24]. Laser therapy poses the risk of fiber rupture or blood vessel puncture, potentially leading to complications post-surgery such as subcutaneous congestion, formation of backbone in the large saphenous vein, localized sclerosis or nodules in the lower limb, skin burns, thrombotic phlebitis, and similar issues. The thermal effect generated by the laser can easily harm nearby saphenous nerve fibers, resulting in abnormal sensations within the respective distribution area. Therefore, adjusting the laser's power output and optimizing the speed of fiber retreat may help reduce the incidence of these complications.

Sclerotherapy

Sclerotherapy serves as a viable treatment option for individuals experiencing varicose veins in the lower limbs. It involves the injection of chemical agents directly into the affected veins to induce inflammatory closure. This method is particularly effective for addressing issues like capillary dilation and venous congestion, targeting superficial varicose veins as well as the main trunks of the small and large saphenous veins.

The administration of sclerosing foam is a common practice in treating varicose veins, comprising a combination of gas and liquid sclerosant solution [25]. The sclerosing solution injected into the bloodstream induces thrombosis by directly damaging the vascular endothelium. This process initiates aseptic inflammatory reactions, leading to tissue fibrosis and permanent occlusion of pathological blood vessels, thereby achieving optimal therapeutic outcomes. Foam sclerotherapy, a modified approach to traditional sclerotherapy, involves creating bubbles of sclerosant using either air or carbon dioxide. These bubbles are then injected into the affected vein under ultrasound guidance [26].

In contrast to the drawbacks associated with surgical procedures, including significant trauma, numerous incisions, notable blood loss, extended hospital stays, and high medical expenses, sclerotherapy offers several benefits. These include straightforward procedures, minimal trauma, outpatient treatment, minimal discomfort, and cost-effectiveness. Moreover, there are no surgical scars on the skin, meeting the patient's aesthetic expectations. However, repeated injections are necessary to alleviate the symptoms, but they do not address the underlying cause of the condition. Additionally, there is a high risk of recurrence and complications such as phlebitis, tissue damage, ulcers, pigmentation issues, and allergic reactions. Consequently, sclerotherapy is rarely used as a standalone treatment for varicose veins; instead, it is often employed as a supplementary therapy following venous ligation. Combining both treatments can offer complementary benefits and is considered a more promising approach for managing varicose veins.

Compression therapy

Due to subtle clinical symptoms, external pressure can complement nursing interventions like rest and limb elevation for primary lower extremity varicose veins. Compression therapy, including medical stockings, elastic bandages, and pneumatic devices, is crucial post-surgery to prevent complications.

Medical elastic stocking therapy

Medical elastic stockings, also known as compression socks, are essential for treating lower extremity varicose veins and preventing complications. They provide sustained therapeutic benefits, such as alleviating leg swelling and discomfort, and supporting postoperative recovery after vein stripping procedures. These garments are widely used due to their convenience and effectiveness [27].

By enhancing the density and resilience of elastic fibers in the ankle and calf regions, medical compression stockings create a gradual pressure gradient, decreasing from the ankle upwards. This promotes the return of venous blood flow, prevents stasis in the lower limb veins, and reduces swelling by stimulating muscle contractions to apply pressure to the blood vessels [28]. Medical compression stockings are classified into various pressure levels: low-pressure for preventive and postoperative care, middle-pressure for treating superficial varicose veins, and high-pressure for severe cases. Accurate measurements of the ankle and calf circumference are essential for selecting the appropriate size, with preference for a smaller size if measurements fall between two options.

Medical compression stockings provide benefits in preventing postoperative deep vein thrombosis and reducing edema following lower extremity varicose vein surgery. However, they have drawbacks like time-consuming application and potential allergenic reactions due to their content. Additionally, the process of donning these stockings may aggravate wounds and cause discomfort, while their warmth may be uncomfortable for patients, leading to surgery postponement [29]. The utilization of gauze dressings following surgical intervention for varicose veins heightens the risk of displacement during the application of compression stockings. This displacement can lead to the exposure of wounds or necessitate the reapplication of dressings, thereby introducing inconvenience and potentially impeding the wound healing process.

Intermittent pneumatic compression therapy

Intermittent pneumatic compression (IPC) therapy involves the sequential application of compression, starting from the foot and progressing upwards to the thigh. It utilizes various components, including the plantar venous pump, ankle-calf venous pump, calf venous pump, and calf-thigh venous pump. Essential aspects of IPC therapy include the sequential inflation of chambers, the application of appropriate pressure, ensuring sufficient inflation duration to facilitate fluid movement, and maintaining consistent pressure without deflation of distal chambers during compression [30].

IPC involves the application of inflatable sleeves encircling the leg, either around the calf or extending to both calf and thigh. These sleeves inflate and deflate intermittently, exerting pressure on the leg to enhance venous return. In certain systems, inflation occurs sequentially, and the frequency of inflation can vary based on the device's design and refill mechanism [31]. IPC facilitates fluid circulation through consistent mechanical massage, harmonizing with natural blood flow. This boosts limb microvascular expansion and enhances circulation. By cyclically inflating and deflating, mimicking vascular constriction and dilation, IPC mitigates blood stagnation, diminishes tension, and fosters varicose vein flow. The gentle massage poses no risk of skin irritation, ensuring long-term safety. IPC systems feature distinct gas and circuit paths, guaranteeing electrical safety. They're adaptable to various compression bladder configurations and inflation patterns, offering versatility in managing edema. This non-invasive, painless therapy significantly alleviates patient burden and can be broadly integrated into clinical practice [30][32]. The precise mechanisms by which IPC exerts a positive influence on the treatment of varicose veins of the lower extremities are not yet fully understood by science [33].

Elastic bandage therapy

Elastic bandages serve as a cornerstone in managing and preventing varicose veins in the lower limbs. Their therapeutic impact hinges on the exertion of pressure on the limb, which fosters improved venous blood circulation, consequently alleviating pain and reducing swelling. Moreover, these bandages commonly function as a foundational layer, ensuring the stability of dressings and effectively mitigating limb edema [34]. The application of elastic bandages should commence from the far end towards the nearer area of the affected limb. It's crucial to exert higher pressure on the distant side and gradually decrease it towards the proximal region to facilitate optimal blood flow. The proper tightness and pressure level are pivotal for successful treatment outcomes, as inadequate compression might result in postoperative complications, compromising the efficacy of the intervention. Compression therapy encompasses a spectrum of options, ranging from single to multi-layer bandages, and elastic bandages come in various configurations, including short, medium, and long-stretch variants. Selection of the appropriate elastic bandage should be contingent upon factors such as ease of application and patient compliance [35].

In contrast to medical-grade elastic stockings, the practicality of elastic bandages presents inherent limitations. Their application demands precision and control, aspects often challenging for patients. Proper adjustment of pressure during bandaging proves elusive, potentially compromising therapeutic outcomes. Inadequate compression may undermine the bandage's efficacy, while excessive tightness carries risks of discomfort, edema, compromised circulation, and, in severe cases, tissue ischemia.

2. Summary

Surgical intervention remains a primary treatment for lower extremity varicose veins, involving techniques like high ligation and stripping, along with valvuloplasty for addressing deep venous valve insufficiency. While effective, surgical procedures have limitations and contraindications, including arterial insufficiency, deep vein thrombosis, and pregnancy.

Minimally invasive therapies like sclerotherapy and intracavity laser therapy are gaining popularity due to their efficacy, safety, and cost-effectiveness. However, these methods also have their challenges, such as the risk of complications and higher recurrence rates compared to surgical interventions.

Compression therapy, utilizing medical elastic stockings and elastic bandages, plays a crucial role in postoperative care and symptom management. While elastic stockings offer convenience and effectiveness, elastic bandages require precision in application to ensure optimal therapeutic outcomes.

Intermittent pneumatic compression therapy is another non-invasive option, promoting venous return through mechanical massage. Despite its effectiveness, the precise mechanisms of action remain unclear.

Overall, a comprehensive approach combining surgical interventions with minimally invasive techniques and compression therapy offers promising outcomes in managing lower extremity varicose veins.

Disclosures

Author'scontribution:

Conceptualization: Katarzyna Bil, Aleksandra Rykucka, Iga Ślesicka

Methodology: Aleksandra Latała

Software: Magda Przestrzelska

Check: Justyna Kiełbasa, Marcin Wąs

Formal analysis: Zuzanna Tomczewska, Magda Przestrzelska

Investigation: Agata Kowalczyk, Natalia Zozula

Resources: Zuzanna Tomczewska

Data curation: Aleksandra Rykucka

Writing–rough preparation: Justyna Kiełbasa, Natalia Zozula

Writing–review and editing: Aleksandra Latała, Marcin Wąs, Agata Kowalczyk

Visualization: Natalia Zozula

Supervision: Aleksandra Rykucka

Project administration: Katarzyna Bil, Iga Ślesicka

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