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Review article

Endovascular Technique and treatment of varicose veins of the lower limbs: a review

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Abstract

Varicose veins are twisted, dilated veins most commonly located on the lower extremities. Risk factors include chronic cough, constipation, family history of venous disease, female sex, obesity, older age, pregnancy, and prolonged standing. The exact pathophysiology is debated, but it involves a genetic predisposition, incompetent valves, weakened vascular walls, and increased intravenous pressure. A heavy, achy feeling; itching or burning; and worsening with prolonged standing are all symptoms of varicose veins. Potential complications include infection, leg ulcers, stasis changes, and thrombosis. Some conservative treatment options are avoidance of prolonged standing and straining, elevation of the affected leg, exercise, external compression, loosening of restrictive clothing, medical therapy, modification of cardiovascular risk factors, reduction of peripheral edema, and weight loss. Various treatment options are available; however, the newer endovascular options are easy, highly effective, safe, and quick in relieving symptoms. Endovascular treatment options include thermal ablation, mechanochemical ablation, and foam sclerotherapy. This review article briefly describes various scoring systems used in varicose veins, the role of imaging, different management techniques, and guidelines proposed in the management of this condition.

Keywords: Endovascular, Varicose veins, Sclerotherapy

Introduction

A chronic venous disorder is a clinical condition characterized primarily by weakness within the vein wall and associated with valvular dysfunction and venous reflux. Chronic venous insufficiency (CVI) of the lower limb is a syndrome that includes all the signs and symptoms occurring due to persistent venous hypertension [1]. Patients present with a spectrum of symptoms, including prominent leg veins (telangiectasias, varicosities), heaviness, pain, itching, swelling, muscle cramps, discoloration, and ulceration. Varicose veins are generally identified by their twisted, bulging, superficial appearance on the lower extremities [1-3]. They also can be found in the vulva, spermatic cords (varicoceles), rectum (hemorrhoids), and esophagus (esophageal varices). Varicose veins are a common problem, with widely varying estimates of prevalence. In general, they are found in 10 to 20 percent of men and 25 to 33 percent of women [4].

Etiology

The etiology of varicose veins is multifactorial and may include: increased intravenous pressure caused by prolonged standing; increased intra-abdominal pressure arising from tumor, pregnancy, obesity, or chronic constipation; familial and congenital factors; secondary vascularization caused by deep venous thrombosis; or less commonly, arteriovenous shunting [5]. Shear forces and inflammation have recently been recognized as important etiologic factors for venous disease. Venous disease resulting in valve reflux appears to be the underlying pathophysiology for the formation of varicose veins. Rather than blood flowing from distal to proximal and superficial to deep, failed or incompetent valves in the venous system allow blood to flow in the reverse direction [6, 7]. With increased pressure on the local venous system, the larger affected veins may become elongated and tortuous. Although no specific etiology is noted, in most cases the valvular dysfunction is presumed to be caused by a loss of elasticity in the vein wall, with failure of the valve leaflets to fit together.

An excellent and thorough understanding of the lower limb venous anatomy and physiology is warranted for an effective treatment. Different treatment options include traditional surgical management and newer endovascular treatments. Endovascular options include thermal ablation, mechanicochemical ablation (MOCA), and foam sclerotherapy.

Principle and mode of action of the different endovascular techniques

1. Radio frequency

Radio frequency (RF) provides controlled thermal energy that raises the temperature of the vascular wall. This produces, on the one hand, a destruction of the entire intimal surface and, on the other hand, a contraction and thickening of the collagen fibers contained in the adventitia and, above all, in the middle. The contraction of collagen fibers is secondary to a disconnection of the helical molecular structure with maintenance of heat-resistant intramolecular bridges. Lesions of myocytes and of fibroblasts. In this way, the venous diameter is greatly reduced measured by the contraction and thickening of the collagen fibrils, but also by the spasm induced by the rise in temperature. These phenomena cause secondarily a fibrous evolution, in most cases progressive, which causes occlusion of the venous lumen. The thermal energy that is applied with the catheter is produced with a specific generator [8].

2. Endovenous laser treatment

The most widely used endovenous laser (LEV) is the diode laser. The wavelength of the light applied by the laser fiber is variable. Those that act on hemoglobin (810, 940 and 980 nm) are distinguished from those that act on water (1,319, 1,320, 1,470 and 1,500 nm).

Its thermal action occurs in three complex and successive stages:

- conversion of light into heat;
- heat transfer by conduction to adjacent tissues, that is, to the venous wall;
- the third stage is thermochemical. Produces the destruction of tissues as in RF.

Initially, uncoated fibers were used, but have been replaced by radial fibers.

3. Ultrasound-guided foam sclerotherapy (EEE)

Injection of a sclerosing agent into the venous lumen is done in order to obliterate it. It is an old technique, but the use of ED and the foam form has greatly increased the safety and effectiveness of the sclerosing agent. Its mechanism of action is known in detail. At first, the endothelial cells are destroyed, exposing the collagen fibers, which, in turn, are denatured. The ideal end result is fibrous venous lumen obstruction identical to that obtained with RF or LEV [9].

4. Cryosclerosis and cryostripping

From the point of view of terminology, only cryosclerosis should be classified in endovascular ablation methods; cryostripping is a variety of phleboextraction. The foundation of cryosclerosis is to use the properties of cold to destroy the vein. A cryogenic probe is introduced into the lumen of the vein to be treated, the end of which is cooled with nitrogen protoxide. In cryosclerosis, nitrogen protoxide was released into the probe sequentially and in a staggered fashion while the probe was mobilized. This produced obliteration of the lumen and fibrosis of the tunics of the treated vein with each pulse. This technique is described for informational purposes, because it has been abandoned due to its poor results related to frequent repermeabilization of the venous lumen.

5. Steam

This technique, introduced by Milleret in 2006 to minimize the costs of other thermal endovascular ablations (laser, RF), consists of injecting boluses of water vapor at 120 ◦C into the venous lumen, each of which applies 60 J. The steam is injected under pressure through two side holes at the end of a very flexible probe [10].

6. Pharmacochemical ablation

Its rationale is to reduce the limitations of the efficacy of thermal ablation and sclerotherapy by combining their advantages. To combine the two methods, a rotating wire rotating at 3,500 revolutions per minute is introduced into the venous lumen, injuring the intima and creating a spasm of the vein while infusing the sclerosing agent in liquid form through a hole at the end catheter.

7. Thermochemical ablation

Like Clari Vein pharmacochemical ablation, LEV can be used in conjunction with EEE: laser assisted foam sclerotherapy or LAFOS (laser assisted foam sclerotherapy) technique [11]. The reduction of the caliber of the venous light induced by the action of the 2,100 nm Ho-YAG laser on the media facilitates the action of the sclerosing foam on the intima [12].

Table1. Clinical Tests Used to Detect Venous Reflux in Patients with Varicose Vein

Test	Description	Finding	Sensitivity (%)	Specificity (%)	Positive Predicative Value (%)	Negative Predictive Value (%)
Tap test	With the patient standing, a hand is placed over the SFJ, and the LSV is tapped at the level of the knee with the other hand.	A palpable transmitted impulse denotes that the LSV is distended with blood. The SFJ is then tapped and the presence of a retrograde, palpably transmitted impulse at the knee indicates incompetence of valves between the SFJ and the LSV, with reflux in the proximal LSV.	18	92	70	47
Cough test	With the patient standing, a finger is placed on the thigh over the SFJ.	A palpable thrill or impulse on coughing in indicative of an incompetent SFJ.	59	67	64	38
Perthes test	With the patient standing, a tourniquet is applied below the knee. The patient is directed to complete 10 heel raises.	If the varicosities empty, the site of reflux is above the tourniquet. If the veins remain distended, the site of reflux is below the tourniquet.	97	20	55	13
Trendelenburg test	With the Patient in the supine position, the affected leg is elevated to 45 degrees to drain the varicosities. A tourniquet is applied just below the SFJ, and the patient is directed to stand.	Failure of the varicosities to fill indicates that the SFJ is the site of reflux.	91	15	52	38

NOTE: Assume a pretest probability of 50 percent, and use duplex Doppler ultrasonography as the reference standard.
LSV = long saphenous vein; SFJ = saphenofemoral junction

Treatment

Treatment options for varicose veins include conservative management, external laser treatment, injection sclerotherapy, endovenous interventions, and surgery. The indications for treatment are largely based on patient preference. Choice of treatment is also affected by symptoms, cost, potential for iatrogenic complications, available medical resources, insurance reimbursement, and physician training, as well as the presence or absence of deep venous insufficiency and the characteristics of the affected veins. Vascular surgical intervention for venous insufficiency may be indicated in patients with aching pain and leg fatigue, ankle edema, chronic venous insufficiency, cosmetic concerns, early hyperpigmentation, external bleeding, progressive or painful ulcer, or superficial thrombophlebitis (Table 1).

External leaser treatment

Multiple laser machines that deliver various wavelengths of light through the skin and into the blood vessels are available to treat varicose veins. The light is absorbed in the vessels by hemoglobin, leading to thermocoagulation. Types of lasers include pulsed dye, long pulsed, variable pulsed, neodymium doped yttrium aluminum garnet (Nd:YAG), and alexandrite lasers. Potentially, any small, straight vein branch is amendable to external laser ablation. However, laser therapy has typically been used on telangiectasias and smaller vessels rather than on larger veins. Long-pulsed lasers have been shown to completely clear veins with diameters less than 0.5 mm. For veins with diameters of 0.5 to 1.0 mm, improvement but not clearance is achieved (Table 2 [13]).

Management

Conventional Surgery

Historically, surgery is the best known treatment for varicose veins, especially when the greater saphenous vein is involved. However, literature does not consistently support surgery as the definitive treatment option. Most surgical techniques involve using multiple smaller incisions to reduce scarring, blood loss, and complications [14].

Surgical management may reduce the risk of complications of varicose veins. Surgical correction of superficial venous reflux reduces 12-month ulcer recurrence. In addition, surgical management of venous ulcers leads to an 88 percent chance of ulcer healing, with only a 13 percent risk of ulcer recurrence over 10 months.

The simplest surgical procedure is ligation, which involves tying off the enlarged vein in portions of the leg, thigh, and groin [15]. Potential complications include recurrence and worsening of intravenous pressure in tributary veins. Phlebectomy and stripping are probably the best known procedures; however, they are more of a collection of procedures than single techniques. For phlebectomy, the varicose vein is mapped and marked on the skin using visual skin changes or duplex Doppler ultrasonography while the patient is standing [16]. The patient is then placed in a supine position, and a series of perpendicular 1- to 2-mm stab incisions are made over the vein several centimeters apart [17, 18]. The saphenous vein is identified in the groin, brought to the surface via a small incision, and ligated. The vein is hooked and brought to the surface at the next incision site [6]. It is then pulled and dissected proximally and distally at each incision site to release it from the surrounding tissues and to sever any connections to

Table 2. Treatment Options for Varicose Veins [13]

Treatment option	*Comment*
Conservative measures **Compression (e.g., bandages support stockings, intermittent pneumatic compression devices)**	Support stockings can provide relief from discomfort.
Elevation of the affected leg	Elevation may improve symptoms in some patients
Lifestyle modification	Examples include avoidance of prolonged standing, exercise, loosening of restrictive clothing, modification of cardiovascular risk factors, and reduction of peripheral edema.
Weight loss	Weight loss may improve symptoms in patient who are obese.
Endovenous or interventional therapy **Endovenous obliteration** **External laser therapy** **Sclerotherapy**	Randomized Controlled trials comparing Clinical effectiveness and cost-effectiveness are lacking.
Surgery **Ligation** **Phlebectomy** **Stripping**	Historically, surgery has been The most widely recommended treatment option

tributary or deeper perforating veins. This process is repeated distally. The vein can be removed in a long strip or in multiple smaller pieces depending on the size and shape of the vessels, as well as the patient's vascular pathology. Alternatively, the greater saphenous vein can be ligated and incised at the groin. A stripper is inserted into the vein near the knee and moved proximally. The stripper is then attached to the proximal end of the vein and pulled distally, removing it [19, 20].

Typically, surgical procedures are done in a hospital operating room or in an outpatient surgical center. These procedures are associated with significant cost and risk of complications from anesthesia [21, 22]. Potential postsurgical complications include bleeding, bruising, and infection. In addition, a new blood vessel may form after the procedure, with the risk of neovascularization estimated to be as high as 15 to 30 percent.

Modern Saphenous Ablation

Prolonged exposure to high-frequency alternating current RF energy results in total loss of vessel wall architecture, disintegration, and carbonization. Application of this knowledge has allowed treatment of the greater saphenous vein by intraluminal techniques [23]. Preliminary results obtained in 389 patients treated with RF energy were clouded by third-degree burns of the skin, saphenous nerve injury, periphlebitis, peroneal nerve injury, and wound infection [24]. Now, elimination of saphenous vein reflux is achieved with use of RF heating. The VNUS vein treatment system, which uses the Closure catheter (VNUS Medical Technologies, Sunnyvale, CA), is the most used system in the United States and Western Europe [25, 26]. This system uses electrodes specifically designed for treatment of the saphenous vein and allows monitoring of electrical and thermal effects of the catheter. Clinically, the device produces precise tissue destruction with minimal formation of thrombus. Bipolar electrodes are used to heat the vein wall. The net effect is venous spasm and collagen shrinkage, which produces maximal physical contraction [27].

In practice, elimination of venous blood is accomplished by Esmarch bandaging and proximal saphenofemoral junction compression. Saphenous vein ablation has been performed with use of intravenous sedation and tumescent anesthesia alone and with general anesthesia with and without proximal saphenofemoral ligation. Acute closure was achieved in 93% of 141 saphenous veins in the first large series to be reported, and the 2-year continued closure rate exceeds 90% with only a small fraction of the original anatomic failures requiring repeat treatment [28].

Surgical series have shown that undesirable outcomes after saphenous stripping are evident quite early. It is acknowledged that surgical stripping results in recurrent truncal vein reflux in 20% of limbs and that 73% of limbs destined for recurrent varicosities at 5 years have already had them at 1 year. Therefore, the early results of the use of the VNUS Closure system seem destined to be comparable to stripping in the long term [29].

Goldman, who has taken the lead in use of the endovenous Closure system and the laser 810-nm diode in our institution, uses large amounts of tumescent anesthetics containing 0.1% lidocaine with epinephrine [30]. Intraoperative ultrasound (US) monitoring insures that the greater saphenous vein is separated from the skin by the tumescent anesthesia, thereby avoiding skin burns.

Performing endovenous obliteration of the saphenous vein without dissection of the saphenofemoral junction violates a cardinal rule in saphenous vein surgery [31]. This holds that each of the tributaries must be individually divided. It is advocated by some that each of the tributaries should be dissected back beyond their primary and even secondary tributaries. Careful duplex evaluation of saphenous obliteration by Pichot et al has revealed marked shrinking and obliteration of the saphenous vein itself but with preservation of tributaries to the saphenofemoral junction. Sixty limbs treated with saphenofemoral junction ligation and division of tributaries have been compared to 120 limbs treated without high ligation. Of the 49 limbs with high ligation that underwent sufficient follow-up, 2% developed recurrent reflux by 6 months and, in the 97 corresponding limbs without high ligation, 8% developed recurrent reflux (P = NS). In limbs followed for 12 months, no new instances of reflux developed. Actuarial recurrence curves were not different with saphenofemoral ligation versus without it and the experience predicted a greater than 90% freedom from recurrent reflux and varicosities at 1 year for both groups [32].

The issue is not settled, but it is acknowledged that, should a tributary develop reflux and prove to be a source of recurrent varicosities, the problem can be managed without further surgery by using sclerotherapy. Many surgeons would prefer ambulatory phlebectomy at this point, but in either event, the problem is not a major deterrent to the use of endovascular saphenous vein obliteration by RF energy without saphenofemoral ligation[43].

The most serious complication of varicose vein surgery is deep venous thrombosis and deep venous thrombosis with pulmonary embolization. In the Closure registry, three of 522 patients were found to have deep venous thrombosis (0.57%). Pulmonary embolus was encountered in 0.17% of cases. A less serious but troublesome complication is dysfunction in the territory of the greater saphenous nerve. This was found in 12.5% of limbs treated by the Closure technique at 1 week, 2.75% at 12 months, and 3.6% at 24 months (data on file, VNUS Technologies, Inc.). In a number of early reports of varicose vein surgery, the incidence of pulmonary embolization has ranged from 0.4% to 0.6% and paresthesia's have occurred in 10%–20% of cases. Methods of detecting deep venous thrombosis have been cumbersome in the period in which varicose vein surgery has been reported, but it is acknowledged that approximately 1% of such patients will encounter deep venous thrombosis [31-33].

Conclusion

Venous insufficiency of the lower limb is a widespread condition that, when diagnosed and treated early, can prevent disease progression and complications associated with the procedure. Principles of ultrasound and intervention are well understood by the interventional radiologist giving them the skills to treat the condition with utmost accuracy ideally. Studies have shown that endovascular treatment offers equal long-term efficacy similar to surgery. Nonthermal endovenous ablations are newer techniques but are in need of long-term outcome data.

Author contribution

Conceptualization and design, AA and AA and SNI and AA; Analysis and interpretation, AA and AA; Writing-Original draft preparation, AA and AA and SNI and AA; Writing-Review & editing, AA and AA and SNI; Approval of manuscript, AA and SNI. All authors read and approved the final manuscript.

Conflict of interest

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Ethical declaration

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