Venous Ulcers: New Options in Treatment: Minimally Invasive Vein Surgery

Honesto Poblete, MD^{a,*}, Steven Elias, MD^{a,b}

^aCenter for Vein Disease, Mt. Sinai School of Medicine, New York, NY, USA

^bCenter for Vein Disease, Englewood Hospital and Medical Center, Englewood, NJ, USA

KEYWORDS:

minimally invasive vein surgery;
PAPs;
SEPS;
venous ulcer;
MIVS;
radiofrequency ablation;
laser ablation;
perforator ablation

Abstract Venous disease has a spectrum of presentations. The most advanced state of chronic venous insufficiency (CVI) managed by wound care specialists being ulceration of the lower extremity. The goal of all treatments for advanced venous disease is to decrease ambulatory venous hypertension. Treatment can be divided into exogenous and endogenous methods. Exogenous methods include those applied externally such as compression, elevation, debridement and wound dressings. Endogenous methods treat the underlying venous pathology either due to venous valvular dysfunction or venous obstruction leading to venous hypertension. Recently, significant advances in endogenous methods have evolved. The development of a new concept, minimally invasive vein surgery (MIVS), has improved upon traditional, open, invasive treatments of venous disease. MIVS techniques are performed percutaneously, with minimal anesthesia, no incisions and rarely require hospital admission. This article summarizes the concept of MIVS, describes each method of MIVS and its complementary role in the management of venous leg ulcers patients.

© 2009 Elsevier Inc. All rights reserved.

The goal of treatment for advanced venous disease is to decrease ambulatory venous hypertension. Various strategies are employed. These can be divided into exogenous and endogenous treatments. Exogenous methods concern those employed from the outside of the limb: compression, elevation, debridement, and wound dressings. Endogenous modalities treat from inside the limb the underlying venous pathology due to venous valvular dysfunction or venous obstruction. Traditional endogenous procedures include stripping, ligation, and phlebectomy. All these procedures require incisions, anesthesia, perhaps hospitalization, and significant discomfort. Newer minimally invasive vein surgery (MIVS) procedures now exist. These are all same-day, outpatient procedures, usually involving local anesthesia.

Most can be performed percutaneously without incisions. Patients ambulate the day of the procedure. Morbidity is less than 1%. The wound care algorithm of venous ulcers should now include MIVS. This article summarizes the concept of MIVS and describes each method and MIVS's complementary role in the management of venous wounds.

Prevalence

Venous disease is thought to have been reported in texts more than 3,000 years old. Leg ulcers were first described by Hippocrates, who noted an association with varicose veins and ulceration.¹ He recommended those with leg ulcers should avoid standing. This concept of relieving the venous hypertension persists, and today relief can be achieved with more rapid healing, minimal morbidity, and less recurrence.

* Corresponding author.

E-mail address: honesto.poblete@mssm.edu

Table 1 Clinical-Etiology-Anatomy-Pathophysiology Classification for Chronic Venous Disease

Classification	Description
C0	Asymptomatic; no visible or palpable signs of disease.
C1	Telangiectasias, or reticular or spider veins (<3 mm)
C2	Varicose veins (≥ 3 mm)
C3	Edema of the legs
C4	Changes in skin and subcutaneous tissue 4A: Pigmentation or eczema 4B: Lipodermatosclerosis or atrophie blanche
C5	Healed, closed venous ulcer
C6	Active, open venous ulcer

The prevalence of venous disease far exceeds that of arterial disease, with 4 to 5 times more cases of venous disease than arterial disease. Venous insufficiency may present as a spectrum of clinical disease from spider veins to long-standing venous stasis ulcers.

The clinical-etiology-anatomy-pathophysiology (CEAP) classification based on manifestations of chronic venous disease was developed in 1994 and revised in 2004.^{2,3} The CEAP system, which ranges from asymptomatic C0 to active ulcer C6, is the most widely used descriptive system for venous disease and provides a systematic guide for its investigation (Table 1).

The Edinburgh Vein Study found the prevalence of chronic venous insufficiency (CVI) was 9.4% in men and 6.6% in women.⁴ The San Diego Population Study found venous trophic changes in 6.2% of the studied population.⁵ McLafferty found a CEAP C4 represented 8% of the population while CEAP C5 or C6 was found in 1.5%.⁶ Venous stasis ulceration has been estimated to represent 58% to 70% of lower extremity ulcers.⁷

The prevalence of venous ulcers has ranged in various studies from 0.1% to 0.63% of the general population.⁸ In the United States this potentially represents up to 1.8 million people with ulcerative venous disease. The prevalence of venous ulcers increases with increasing age. This likely reflects the progression of venous disease leading to the development of lower extremity ulcers. As the population ages, the overall number of patients suffering from venous ulcers is likely to grow.

Etiology and Pathology of Venous Ulcers

The etiology of venous ulcers may have several contributing factors. A history of deep venous thrombosis (DVT) is often found in patients presenting with venous ulceration. The clinical pioneer John Homans recognized in 1916 that postthrombotic ulceration was difficult to treat. He described it as “always intractable to palliative treatment, generally

incurable by removal of varicose veins alone and ... must be excised to be cured.”⁹ In the Lewisham Hospital series, a history of venous thrombosis was identified in 58% of patients with venous ulcers.¹⁰

Acquired or inherited thrombophilias have been investigated in the development of venous ulcers. In a cohort of 88 patients with chronic venous ulceration, thrombophilia was detected in 41%.¹¹ The high incidence of thrombophilia in this cohort may indicate an important mechanism of ulceration in these patients.

Venous hypertension is strongly correlated with the development of leg ulceration. Nicolaides showed a direct relationship between ambulatory foot vein pressure and ulceration. In patients with an ambulatory foot vein pressure of 30 mm Hg or less, leg ulceration was not seen, while those with a pressure greater than 90 mm Hg experienced consistent ulceration.¹²

The pathophysiology of venous ulcers involves the derangement of normal venous outflow due to vein wall fibrosis and valvular incompetence. The static blood increases the venous pressure, inducing a hypertension, and may be seen grossly as varicosities. The progression to ulcer formation results from the extravasation of cytokines, leukocytes, red blood cells, and platelets, which contribute to an inflammatory response that induces changes in the surrounding subcutaneous tissue and skin. These factors first induce fibrosclerotic changes in the skin and eventually lead to venous ulceration.⁸

Diagnosis

The evaluation of lower extremity ulcers should determine the causal factors, including arterial, venous, or mixed. Other, rarer causes, such as vasculitides, malignancy, or pyoderma, should be entertained after the more common causes have been ruled out.

Arterial insufficiency resulting in lower extremity ulcers indicates a threatened limb. Appropriate evaluation may include determination of ankle-brachial indices or diagnostic imaging in the evaluation of arterial supply. Compression should not be done in patients with severe ischemia, and evaluation by a vascular specialist should be done to determine need for intervention or nonoperative therapy.

Venous ulcers are often accompanied clinically by the signs of chronic venous insufficiency, including edema, induration, hyperpigmentation, and presence of varicose veins. The location is also most commonly over the medial or lateral malleolus and the lower third, or “gaiter area,” of the leg, but location can vary for both arterial and venous ulcers. Duplex ultrasound is the diagnostic modality of choice to confirm presence of venous disease. Venous insufficiency is indicated in the superficial system by reversal of flow or valve closure time of >0.5 second and in the deep system, >1.0 second. In the perforator system, a reversal of flow time of >0.5 second and vein diameter

>3.0 mm indicate incompetence, and regardless of flow dynamics, perforator veins with a diameter >4.0 mm should be considered incompetent.¹³

Mixed disease may be present and can affect the therapies appropriate for ulcer management. Patients with mild arterial disease (ie, an ankle-brachial index [ABI] >0.8) in the presence of venous ulcers should be able to tolerate adequate compression and definitive venous procedures without arterial compromise to the limb. In those with an ABI of 0.5 to 0.8, the patient may be treated with reduced compression, that is, 15 to 25 mm Hg and evaluation of the arterial system.¹⁴

Treatment

Nonoperative Therapy

Local wound care is integral in the care of venous ulcers. The wound should be assessed for infection, inflammation, exudates, and necrosis. The presence of any of these may retard healing. Debridement of all necrotic tissue should be done by mechanical or enzymatic techniques as needed. The presence of infection should be treated with appropriate antibiotics and if severe and extending to surrounding healthy tissue, it may require systemic therapy. Copious drainage is often seen in venous ulcers, especially at initial evaluation, and a local dressing with good absorptive property should be chosen. Dressings such as alginate, foams, or other highly absorptive dressings may be employed to control ulcer drainage.

Control of edema is essential for ulcer healing, and compression, alone or in conjunction with operative therapy, is a mainstay of venous ulcer therapy. Several modalities and degrees of compression are available to the clinician for treatment of venous ulcers. The variety of compression systems available makes choosing the appropriate therapy difficult, but generally a high-compression dressing (>25 mm Hg) is most effective in treatment.¹⁵ The patient's ability to tolerate the dressing and any degree of arterial ischemia will impact the utility of these dressings.

Surgery in the treatment of venous ulcers has been studied in several randomized controlled trials. The Effect of Surgery and Compression on Healing and Recurrence trial compared compression alone with compression plus surgery of the superficial system in patients with superficial or superficial and deep venous incompetence.⁷ The trial showed no difference in either group at 24 weeks but showed significantly reduced 12-month recurrence rates in the compression-plus-surgery group (12%) compared with the compression-alone group (28%). Long-term follow-up of the group showed the reduced recurrence was maintained at 3 years, with recurrence of 56% in the compression-alone group and 31% for the compression-plus-surgery group.¹⁶

Saphenous Incompetence

Surgery for the superficial venous system of the lower extremities has evolved significantly in recent years. For the great and small saphenous veins, stripping and ligation was the most popular method for most of the later 20th century. The standard procedure involves the exposure of the distal saphenous vein at the level of the knee or ankle and passage of a stripper to the level just distal to the sapheno-femoral junction. The great saphenous vein is then ligated, stripped, and removed through the skin incision. Similar techniques can also be employed for the small saphenous vein if incompetence is present. The procedure is usually done on a same-day basis, with a patient recovery time of 2 to 3 weeks. Saphenous vein stripping and ligation is a well-established technique with proven benefits in treatment of venous disease.

Less-invasive alternatives to vein ligation and stripping were developed in the year 2000 and have been employed widely since. Endovenous ablation using either radiofrequency (RF) or laser energy has been performed at increasing rates and now supersedes conventional vein stripping and ligation (Figure 1). The successful treatment of superficial incompetence by endovenous ablation has been shown to be comparable to results from surgery in several randomized controlled trials.^{17,18} The reported advantages of these techniques are decreased pain and bruising at the operative site, no incisions, and decreased recovery time for the patient. Complication rates are very low in endovenous ablation. The most common are minor and include superficial thrombophlebitis, pain, cellulitis, and hematoma and usually do not require hospital admission. Deep vein thrombosis is also a rare complication that can occur when thrombus induced by venous ablation abuts into the femoral vein.¹⁹ We find this complication can be avoided by performing ablation an adequate distance (2 cm) from the sapheno-femoral junction.

Compared with stripping, endovenous ablation also reduces recurrence rates (neovascularization) in the groin. Important factors in the success of endovenous ablation are accurate access and delivery of adequate energy for contraction of the vein wall and ablation of the lumen. The 2 energy delivery devices available use either radiofrequency (VNUS Technologies) or laser energy. Residual varicosities leading to the venous ulcer may be adjunctively treated with phlebectomy or ultrasound-guided sclerotherapy to further reduce hypertension.

Perforator Incompetence

Incompetent perforator veins (IPVs) may significantly contribute to lower extremity venous hypertension. Perforator incompetence is thought to arise from several possible causes, such as postthrombophlebitic changes or longstanding venous incompetence as a result of deep vein

Figure 1 ClosureFast catheter and generator.

thrombosis involving the perforator valves. The presence of IPVs in venous ulcer disease may exacerbate symptoms, prevent ulcer healing, or predispose to recurrence. The treatment of IPVs has traditionally employed open exposure and subfascial ligation, also known as the Linton procedure.²⁰ Open perforator ligation showed a high wound complication rate of 20% to 50% as well as high recurrence rates of up to 22% at 50 months' follow-up.²¹ Postoperative pain was usually significant, requiring narcotic analgesics, and often involved an in-hospital stay of 3 to 5 days.

In attempts to minimize the drawbacks of IPV ligation, endoscopic techniques were developed. Subfascial endoscopic perforator surgery (SEPS) involved the endoscopic access and identification of IPVs and their ligation.^{1,22-24} The technique's advantages over the open procedure were that the skin incisions were remote from the site of ulcer and avoided the damaged and potentially infected ulcerated skin. The decreased incisional size also reduced postoperative pain. The reported wound complication rates of 6% to 7% are much less than for the open procedure. SEPS improved on the technique of perforator ligation and was done as an outpatient procedure. The disadvantages of the procedure include need for regional or general anesthesia and incidence of nerve injury. It can be technically difficult to perform, and the accessibility to perforators near the malleolus can be limited because of angulation of the endoscopic instruments in the small subfascial space.

Advances in endovenous treatment of veins have allowed for the development of percutaneous ablation of perforators (PAPs). This recently coined term²⁵ was described conceptually as early as 1974, when liquid sclerosant was used in ablation of incompetent perforating veins, initially with promising results.²⁶⁻²⁸ PAPs may be performed by several methods although all have the same objectives: (1) ultrasound-guided percutaneous intraluminal access; (2) application of ablative technique within lumen,

leading to vessel occlusion, vein wall contraction, or both; (3) local anesthesia with or without sedation as method of anesthesia; (4) outpatient setting, with no incisions; and (5) simple retreatment if needed.

The advantages of PAPs are that minimal anesthesia is required, often local alone, and it is performed in an outpatient setting. The absence of an incision and wound should yield a near zero wound infection and complication rate. No dissection of tissue is done, as opposed to SEPS and open surgery. Postoperative pain is minimal and readily managed by oral, nonnarcotic analgesics. Recurrence of incompetence or development of new incompetent perforators has been well described, and multiple interventions may be required.^{29,30} If they are, previous performance of PAPs should not make reintervention more difficult, although reintervention may be more difficult in SEPS or open surgery. PAPs is easily repeatable, with minimal morbidity. In SEPS, anatomic considerations may limit veins amenable to ligation. Veins near the malleolus are technically difficult to access in SEPS even for those experienced in SEPS (senior author S.E.). In PAPs, intervention is limited only by proper visualization of the perforating vein. Perimalleolar and even inframalleolar perforators can be accessed and treated. PAPs may also be better accepted by the physician and patient because of the minimal pain and morbidity associated with PAPs.

Theoretical complications include skin injury, nerve injury, and deep vessel injury. The use of thermal energy may lead to collateral damage of surrounding structures, but the senior author (S.E.) has not seen these complications occur. Both PAPs and SEPS may have a steep learning curve. The vessels to be treated are generally in the range of 3 mm to 5 mm and can be difficult to access.

The difficulties in PAPs will be overcome with increased experience in the technique. The technique, if effective in ulcer healing and reduced ulcer recurrence rates, has

Table 2 Method of Percutaneous Ablation of Perforators

1. Place patient into reverse Trendelenburg position.
2. Visualize perforating vein with ultrasound at level of fascia.
 - a. Reconfirm diameter and flow dynamics.
3. Anesthetize skin above perforator.
4. Access perforator under ultrasound guidance.
 - a. Confirm access with aspiration of blood.
 - b. Confirm radiofrequency catheter reading of less than 400 Ω .
5. Inject tumescent anesthesia around perforator.
6. Place patient into Trendelenburg position.
7. Apply compression with ultrasound probe.
8. Deliver ablative thermal energy or sclerosant.
9. Remove catheter or needle.
10. Apply manual compression over treated site for 1-2 min.
11. Apply pressure dressing and wrap treated areas.

several distinct advantages over previous techniques and should be the procedure of choice in appropriate candidates.

Techniques of PAPs

All modalities of PAPs adhere to a basic methodology: (1) ultrasound-guided intraluminal access, (2) delivery of ablative measure (thermal or chemical), (3) confirmation of initial treatment success, (4) follow-up assessment of treatment success (Table 2).

Ultrasound-guided access may be obtained by needle, angiocath, or the radiofrequency stylet (RFS) catheter (VNUS Medical Technologies). The RFS device is currently the only proprietary catheter specifically available for perforator treatment (Figure 2). Laser ablation is currently considered off-label use. For all devices, entry into the IPV is confirmed visually and by aspiration of blood from the lumen (Figure 3). In addition, the RFS catheter (VNUS Medical Technologies) has the ability to measure impedance in ohms and is used as a further confirmatory parameter. A measurement of less than 400 ohms indicates intraluminal position. This measurement significantly enhances successful

Figure 2 Radiofrequency Stylet Device. **Figure 3** Radiofrequency Stylet Catheter Access in Incompetent Perforator Vein.

cannulation. Prior to access, the patient is placed in reverse Trendelenburg position to fully dilate the target vessel. The size of probe will help determine the size of accessing needle. After the patient's skin has been numbed with a small amount of lidocaine, a 16-gauge angiocath can be used for a 600-micrometer laser fiber, or a 21-gauge micropuncture needle may be used for a 400-micrometer laser fiber or the RFS which has the access stylet incorporated into it. Once access has been confirmed, the area for focus of ablative energy or sclerosant should be just deep to the fascia to minimize deep vessel and nerve injury. The patient is then placed in Trendelenburg position to empty the vein and promote good wall apposition. Thermal energy is then delivered to ablate the target vessel (Figure 4). The RF catheter heats the vein to 85°C for 4 minutes in each treated segment. In

Figure 4 Post-Percutaneous Ablation of Perforators With Vein Wall Changes.

Figure 5 Pre-Percutaneous Ablation of Perforators With Flow in Incompetent Perforator Vein.

the laser system, approximately 120 to 150 J should be delivered to the vein. A sufficient length should be treated to assure that the segment just below the fascia but remote from the deep system is ablated. Post-PAPs ultrasound confirms ablation (Figures 5 and 6). Compression dressing is then applied over the treated areas.

When sclerotherapy is used, access is obtained as described. The sclerosant used can be in either liquid form or, more recently, foam. Foam sclerotherapy has been advocated as more effective. Most studies use sodium tetradecyl sulfate (STS) 3% or sodium morrhuate in liquid form, injecting and volumes of 0.5 to 1 mL sclerosant are injected. Care is taken not to inject into the accompanying artery. After infusion, compression is applied with direct pressure over the treated IPV, followed by dressing with wraps or stockings.

Clinical Results of PAPs

Sclerotherapy in PAPs has been employed since 1963 although early attempts did not use ultrasound guidance.³¹ Thibault and Lewis used ultrasound-guided sclerotherapy with an 85% IPV closure rate at 6 months.³² Subsequent studies with a range of sclerosants have found immediate treatment success rates ranging from 90% to 98% and IPV closure rates of up to 75% at 20 months.^{31,32} Rare reported complications occur with migration of sclerosant into the systemic venous system. Most adverse events are minor and most commonly are visual disturbances that are self-resolving.³³ Deep venous thrombosis has also been reported. Extremely rare, the most severe complication reported is stroke, which occurred in the setting of patent foramen ovale.³⁴ Limiting the volume of sclerosant used during a single treatment session should minimize these rare complications.³⁵

Limited data exist regarding RF ablation of perforators. Whiteley and colleagues performed 770 IPV ablations in 506 limbs with 79% occlusion at 1 year.³⁶ Following this report, the RFS designed specifically for IPV ablation was approved by the Food and Drug Administration in 2004. Early data from Chang and colleagues' use of early versions of the

Figure 6 Post-Percutaneous Ablation of Perforators With No Flow in Incompetent Perforator Vein.

RFS showed a 100% procedural success rate. Follow-up in 38 perforators at 6 months showed 87% reflux free, and at 1 year, 91% were reflux free.³⁷

Lumsden and colleagues reported results of RF treatment on 97 IPV in 55 limbs. Perforators were treated percutaneously both intravascularly and extravascularly with RF obliteration.³⁸ The endovascular occlusion rate was 91% at 3 weeks, with extravascular obliteration providing a lower occlusion rate in this study. Two tibial vein thromboses occurred during the study and were treated with anticoagulation without sequelae.

Our own as yet unpublished series involved 20 IPV treated for CEAP class C4 to C6 venous disease. The 1-month occlusion rate was 100%, and the 4-month rate was 90%. The 4-month ulcer healing rate was 90%. Peden reports treatment in 69 IPV with better than 90% success at 6-month follow-up.⁴¹

The early data for laser treatment show comparable results. A report by Proebstle and Herdemann of IPV treatment using laser energy involved 67 IPV in 60 limbs.³⁹ The majority of patients had CEAP class C2 disease, and 1 patient had CEAP class C6. Procedural occlusion rate was 100%. Three-month follow-up included only 16 IPV but did show continued occlusion in these veins. Kabnick reported a 4-month closure rate of 85% in 25 IPV treated with laser energy.⁴⁰ Our own results treating 50 IPV in CEAP classes C4 to C6 with laser energy showed 1-month closure rate of 90%.⁴¹

Murphy compared 100 IPV treated with RF and 100 IPV treated with laser and showed at 6-month follow-up a 90% closure rate for RF and 100% closure for laser.⁴²

The ablation of IPV using thermal energy is a relatively new procedure, and long-term data are not yet available, but the early (6-month to 1-year) results of PAPs have been promising. Chemical ablation has been performed for longer and has, generally, had good results also. The principles of endovenous treatment for great and small saphenous veins apply to PAPs as well: Good technique and adequate delivery of thermal energy provide optimal treatment.

Figure 7 Algorithm for Wound Treatment.

Deep Disease

A significant number of venous ulcer patients have deep insufficiency, scarring, or obstruction. In the recent past, the entity of proximal suprainguinal disease was not appreciated. Raju and Neglen have brought this pathology to treating physicians' attention.⁴³ Outflow stenosis or obstruction in the iliac venous system causes downstream venous hypertension. Catheter-based technology is now available to identify and treat outflow problems. These techniques include ascending venography, magnetic resonance venography, and intravascular ultrasound. Treatment consists of balloon angioplasty and stent placement with good long term success.

Percutaneous prosthetic valves may soon be available for implantation in patients with deep valvular insufficiency.⁴⁴ These valves will also allow the reconstruction of an incompetent deep venous system in a percutaneous manner. The treatment of the deep system pursues the common goal of reduction of venous pressures.

treatment of these ulcers must address any underlying incompetence of the venous system, with the goal of decreasing venous hypertension to promote good wound healing. Traditionally, procedures for the treatment of venous incompetence have involved incisions, significant anesthesia, and in-hospital care. Since the year 2000, MIVS has accomplished the same aims with comparable or improved results. Most MIVS procedures are outpatient procedures, are very well tolerated, and usually require no incisions. Wound centers should adopt the modern combined approach to treatment of venous stasis ulcers: exogenous management; early investigation of venous disease; and aggressive treatment of venous incompetence in saphenous veins, varicose veins, perforator veins, and deep veins (Figure 7). Comprehensive treatment of venous ulcers, addressing local wound care, adequate compression, and correction of underlying venous disease, will promote good wound healing and, more importantly, lower recurrence.

Summary

Venous stasis ulcers require thorough investigation of the vascular system of the lower extremity. Successful

References

1. Hippocrates: De ulceribus and de carnibus. In: Adams F, editor. The Genuine Works of Hippocrates. London, England: Sydenham Society, 1849. p. 325–336.

2. Beebe HG, Bergan JJ, Bergqvist D, et al: Classification and grading of chronic venous disease in the lower limbs: A consensus statement. *Eur J Vasc Endovasc Surg.* 1996;12(4):487–491.
3. Eklof B, Rutherford RB, Bergan JJ, et al: Revision of the CEAP classification for chronic venous disorders: Consensus statement. *J Vasc Surg.* 2004;40(6):1248–1252.
4. Evans CJ, Fowkes FG, Ruckley CV, Lee AJ: Prevalence of varicose veins and chronic venous insufficiency in men and women in the general population: Edinburgh Vein Study. *J Epidemiol Community Health.* 1999;53(3):149–153.
5. Criqui MH, Jamosmos M, Fronck A, et al: Chronic venous disease in an ethnically diverse population: The San Diego Population Study. *Am J Epidemiol.* 2003;158(5):448–456.
6. McLafferty RB, Lohr JM, Caprini JA, et al: Results of the national pilot screening program for venous disease by the American Venous Forum. *J Vasc Surg.* 2007;45(1):142–148.
7. Barwell JR, Davies CE, Deacon J, et al: Comparison of surgery and compression with compression alone in chronic venous ulceration (ESCHAR study): Randomised controlled trial. *Lancet.* 2004;363(9424):1854–1859.
8. Coleridge Smith PD: *Leg Ulcers.* 3rd ed. London, England: Oxford University Press; 2005.
9. Homans J: The operative treatment of varicose veins and ulcers, based on a classification of these lesions. *Surg Gynecol Obstet.* 1916;22:143–158.
10. Negus D, Friedgood A: The effective management of venous ulceration. *Br J Surg.* 1983;70:623–627.
11. MacKenzie RK, Ludlam CA, Ruckley CV, Allan PL, Burns P, Bradbury AW: The prevalence of thrombophilia in patients with chronic venous leg ulceration. *J Vasc Surg.* 2002;35(4):718–722.
12. Nicolaides AN, Hussein MK, Szendro G, Christopoulos D, Vasdekis S, Clarke H: The relation of venous ulceration with ambulatory venous pressure measurements. *J Vasc Surg.* 1993;17(2):414–419.
13. Elias SM, Frasier KL: Minimally invasive vein surgery: Its role in the treatment of venous stasis ulceration. *Am J Surg.* 2004;188(suppl 1A):26–30.
14. Marston W: Evaluation and treatment of leg ulcers associated with chronic venous insufficiency. *Clin Plast Surg.* 2007;34(4):717–730.
15. Cullum N, Nelson EA, Fletcher AW, Sheldon TA: Compression for venous leg ulcers. *Cochrane Database Syst Rev.* 2001;2.CD000265.
16. Gohel MS, Barwell JR, Taylor M, et al: Long term results of compression therapy alone versus compression plus surgery in chronic venous ulceration (ESCHAR): Randomised controlled trial. *BMJ.* 2007;335(7610):83.
17. Rautio T, Ohinmaa A, Perala J, et al: Endovenous obliteration versus conventional stripping operation in the treatment of primary varicose veins: a randomized controlled trial with comparison of the costs. *J Vasc Surg.* 2002;35(5):958–965.
18. Darwood RJ, Theivacumar N, Dellagrammaticas D, Mavor AI, Gough MJ: Randomized clinical trial comparing endovenous laser ablation with surgery for the treatment of primary great saphenous varicose veins. *Br J Surg.* 2008;95(3):294–301.
19. Puggioni A, Kalra M, Carmo M, Mozes G, Gloviczki P: Endovenous laser therapy and radiofrequency ablation of the great saphenous vein: Analysis of early efficacy and complications. *J Vasc Surg.* 2005;42(3):488–493.
20. Linton RR: The operative treatment of varicose veins and ulcers, based upon a classification of these lesions. *Ann Surg.* 1938;107:582–593.
21. Pierik EG, van Urk H, Hop WC, Wittens CH: Endoscopic versus open subfascial division of incompetent perforating veins in the treatment of venous leg ulceration: A randomized trial. *J Vasc Surg.* 1997;26(6):1049–1054.
22. Gloviczki P, Bergan JJ, Rhodes JM, Canton LG, Harmsen S, Ilstrup DM: Mid-term results of endoscopic perforator vein interruption for chronic venous insufficiency: Lessons learned from the North American subfascial endoscopic perforator surgery registry. The North American Study Group. *J Vasc Surg.* 1999;29(3):489–502.
23. Ciostek P, Myrcha P, Noszczyk W: Ten years experience with subfascial endoscopic perforator vein surgery. *Ann Vasc Surg.* 2002;16:480–487.
24. Ting AC, Cheng SW, Ho P, Wu LL, Cheung GC: Clinical outcomes and changes in venous hemodynamics after subfascial endoscopic perforating vein surgery. *Surg Endosc.* 2003;17(8):1314–1318.
25. Elias SM: Will SEPS be around in the next 5 years?. Miami, FL: Presented at: International Vein Conference; 2005.
26. Hobbs JT: Surgery and sclerotherapy in the treatment of varicose veins: A random trial. *Arch Surg.* 1974;109(6):793–796.
27. Thibault PK, Lewis WA: Recurrent varicose veins. Part 2: Injection of incompetent perforating veins using ultrasound guidance. *J Dermatol Surg Oncol.* 1992;18(10):895–900.
28. Guex JJ: Ultrasound guided sclerotherapy (USGS) for perforating veins (PV). *Hawaii Med J.* 2000;59(6):261–262.
29. Roka F, Binder M, Bohler-Sommeregger K: Mid-term recurrence rate of incompetent perforating veins after combined superficial vein surgery and subfascial endoscopic perforating vein surgery. *J Vasc Surg.* 2006;44(2):359–363.
30. van Rij AM, Hill G, Gray C, Christie R, Macfarlane J, Thomson I: A prospective study of the fate of venous leg perforators after varicose vein surgery. *J Vasc Surg.* 2005;42(6):1156–1162.
31. Fegan WG: Continuous compression technique of injecting varicose veins. *Lancet.* 1963;2(7299):109–112.
32. Masuda EM, Kessler DM, Lurie F, Puggioni A, Kistner RL, Eklof B: The effect of ultrasound-guided sclerotherapy of incompetent perforator veins on venous clinical severity and disability scores. *J Vasc Surg.* 2006;43(3):551–556.
33. Guex JJ, Allaert FA, Gillet JL, Chleir F: Immediate and midterm complications of sclerotherapy: Report of a prospective multicenter registry of 12,173 sclerotherapy sessions. *Dermatol Surg.* 2005;31(2):123–128.
34. Bush RG, Derrick M, Manjoney D: Major neurological events following foam sclerotherapy. *Phlebology.* 2008;23(4):189–192.
35. Frullini A, Cavezzi A: Sclerosing foam in the treatment of varicose veins and telangiectases: History and analysis of safety and complications. *Dermatol Surg.* 2002;28(1):11–15.
36. Whiteley MS, Price BA, Scott MJ: Radiofrequency ablation of refluxing great saphenous systems, Giacomini veins, and incompetent perforating veins using VNUS closure and TRLOP technique. *Phlebology.* 2003;18:52.
37. Chang DW, Levy D, Hayashi RM, et al: Percutaneous catheter treatment of perforating vein incompetence using ultrasound guided radiofrequency ablation. Paper presented at: annual meeting of the Society for Clinical Vascular Surgery, Coral Gables, FL. 2005.
38. Lumsden A, Chang D, Peden E, et al: Ultrasound-guided percutaneous radiofrequency obliteration of perforating vein incompetence. Paper presented at: annual meeting of the Society for Clinical Vascular Surgery, Las Vegas, NV. March 2006.
39. Proebstle TM, Herdemann S: Early results and feasibility of incompetent perforator vein ablation by endovenous laser treatment. *Dermatol Surg.* 2007;33(2):162–168.
40. Kabnick L: Perforator vein treatment. In: *Vein Meeting* Uncasville, CT. 2006 June.
41. Elias S, Peden E: Ultrasound-guided percutaneous ablation for the treatment of perforating vein incompetence. *Vascular.* 2007;15(5):281–289.
42. Murphy R: Comparison of radiofrequency and laser for perforator treatment. Paper presented at: American College of Phlebology. Presented November 2006.
43. Neglen P: Chronic deep venous obstruction: Definition, prevalence, diagnosis, management. *Phlebology.* 2008;23(4):149–157.
44. Teebken OE, Puschmann C, Aper T, Haverich A, Mertsching H: Tissue-engineered bioprosthetic venous valve: A long-term study in sheep. *Eur J Vasc Endovasc Surg.* 2003;25(4):305–312.