Treatment of Incompetent Perforating Veins

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Clinical Pearls

1. The current indication to treat perforator reflux is diameter >3.5 mm with reflux >0.5 s in relation to a venous ulcer.
2. Thermal ablation is more effective than ultrasound-guided foam sclerotherapy for treatment of perforator reflux.
3. When treating a perforator with RFA stylet catheter, a drop in impedance to 150–350 Ω insures that the tip of the catheter is in the vein.

Chronic venous insufficiency is a major health problem that affects many people with devastating consequences. Venous valvular incompetence leading to venous reflux and venous hypertension is the pathophysiology of developing venous disease. Increasingly, incompetent perforator veins have been recognized as a contributor to recalcitrant or recurrent venous ulcers. Historically, surgical interruption of perforators has been performed and shown to improve healing of venous ulcers. With advances in technology and comfort in endovenous procedures, percutaneous thermal ablation and ultrasound-guided foam sclerotherapy have gained popularity in the treatment of perforating veins with good success.

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Background

Chronic venous insufficiency (CVI) is a widespread and potentially debilitating problem that affects millions of people. An estimated 23% of Americans have varicose veins including 6% with advanced venous insufficiency resulting in skin changes or ulcerations [1]. The symptoms can range from asymptomatic varicose veins to severe ulcerations. Patients with venous ulcerations are often frustrated by the high recurrence rates and constant care which requires frequent wound care visits, missed work, and social isolation. These factors contribute to significant psychosocial issues and extraordinary healthcare costs [2]. The etiology of CVI has mostly been attributed to genetic factors, but pregnancy, obesity, history of deep vein thrombosis, and jobs requiring long hours of standing have all been shown to contribute [3].

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The etiology of chronic venous insufficiency is venous hypertension. This frequently occurs from incompetent venous valves but can also arise from outflow obstruction [4]. In addition to refluxing superficial axial veins, incompetent perforating veins (IPVs) are also being increasingly recognized as a contributor to the formation and recurrence of venous ulcerations [5]. In normal limbs, perforator veins connect the superficial system with the deep system. There is typically at least one bicuspid valve within the perforator allowing unidirectional blood flow from the superficial to the deep veins. When these valves become incompetent causing venous reflux, local areas of the skin are at risk for ulcer formation [6]. Often when ulcers failed to heal or there is recurrence after successful treatment of the refluxing axial veins, one should look at IPVs as a culprit.

Historically, it was Linton who first suggested in 1938 that interruption of IPVs is a necessary adjunct in the treatment of advanced venous insufficiency. Although rarely done in contemporary practice, several modifications to the original Linton procedure have been described [7–10]. These techniques all had severe wound complications as the incisions are often lengthy and made through fragile skin that was near or at the site of the ulcer [7–10]. The high morbidity of these open procedures led to its eventual abandonment, especially with the introduction of subfascial endoscopic perforator vein surgery (SEPS) by Hauer in 1985 [11].

SEPS is a minimally invasive technique to interrupt calf perforator veins under direct vision using endoscopic instruments placed through small ports remote to the target IPV. Once the leg is insufflated, the IPV is identified and then either ablated with electrocautery or clipped and divided under direct vision [12]. Due to the decreased wound complications by having fewer incisions and away from the problematic skin, SEPS became the procedure of choice to treat IPVs between 1992 and 2008 [13, 14]. In recent years, the emergence of thermal ablations and sclerotherapy performed under ultrasound guidance has completely transformed the techniques of perforator ablation. Today, the open Linton type procedures and SEPS have become more of a historical significance and are very rarely, if ever, performed.

Societal guidelines have classified pathologic perforating veins as incompetent veins near an area of ulceration with a diameter > 3.5 mm and reflux time > 0.5 s [15]. The Society of Vascular Surgery and American Venous Forum recommend against selective treatment of perforating vein incompetence in patients with simple varicose veins (CEAP class C2) but suggest treatment of pathologic perforating veins (outward flow, >0.5-s reflux time, and vein diameter > 3.5 mm) located underneath or near healed or active ulcers (CEAP class C5–C6). The guidelines also recommend the treatment of choice be SEPS, ultrasound-guided sclerotherapy, or thermal ablation (2C recommendation) [15].

Medical Treatment

The initial treatment of patients with CVI is compression. There is good evidence that compression therapy is effective and is the basic treatment for all forms of CVI, including ulceration [16]. The types of compressive therapy range from compression stockings that are easily managed by the patients themselves to complicated medicated wraps that need to be changed by nurses or in wound clinic. Specifically, compressive therapy includes graded compression stockings, paste gauze boots (Unna boot), multilayer elastic wraps, dressings, elastic and nonelastic bandages, and nonelastic garments [16]. However, compliance with compressive therapy varies, and the results can be strikingly different. Mayberry et al. treated 113 patients with venous ulcers with local wound care and compressive therapy and found that the ulcer healing rate was 97% in compliant patients vs. 55% in non-compliant patients. In addition, they reported that ulcer recurrence was 16% in compliant patients vs. 100% in non-compliant patients [17].

The efficacy and cost-effectiveness of conservative therapy over surgical therapy have been studied in the REACTIVE trial, a randomized clinical trial that studied 246 patients with C2 disease. This trial demonstrated that surgical therapy provides more improvement in quality of life and is more cost-effective than conservative treatment alone [18]. Van Gent et al. further demonstrated the same benefit of surgery over conservative management in advanced venous disease (C5–C6) in a prospective multicenter randomized trial [19].

Controversies often surround the need for a period of compression prior to intervention. Although most third-party payers have this requirement, there is no clinical evidence to support this practice. In reality, many patients have difficulty donning compression stockings which often leads to noncompliance.

With respect to perforator veins, it is important to understand that throughout the evaluation and treatment of IPVs, compression remains a basic and essential component of the global treatment plan, regardless of what other treatments are done concurrently or consecutively.

Percutaneous Thermal Ablation Techniques

Endovenous thermal ablation of pathological veins is a minimally invasive percutaneous technique used to cause thrombosis of the treated veins by thermal injury [20]. In order to achieve occlusion and therefore ablate the targeted vein, the laser fiber or radiofrequency-emitting catheter is placed in contact with the IPV wall in order to deliver direct thermal energy. The heat damages the endothelium of the venous walls, resulting in vasospasm and denaturation of the collagen leading to thrombosis and fibrosis of the vein [20, 21]. The two well-described thermal techniques are endovenous laser ablation (EVLA) and radiofrequency ablation (RFA). EVLA was first described in the English literature for the treatment of varicose vein by Bone in 2001 [22]. The RFA catheter, ClosureFast RF catheter (VNUS Medical Technologies, San Jose, Calif), was introduced in 2007 and has gained in popularity in the treatment of IPVs [23, 24].

Percutaneous thermal ablation of IPVs is performed under ultrasound guidance, with local anesthetic typically in an ambulatory setting. The pathological perforator is identified as one that meets reflux criteria (>3.5-mm diameter, >0.5-s reflux time) and adjacent to an active ulcer or area of recently healed ulcer. The patient is placed in reverse Trendelenburg position to cause venous distension which aids in visualization and access. Once the patient is prepped and draped and in proper position, local anesthetic is used to infiltrate the skin, and the perforator is examined with ultrasound in the longitudinal view to plan out the best angle to enter (Fig. 13.1).

Radiofrequency ablation uses a radiofrequency stylet catheter (ClosureFast radiofrequency stylet; Medtronic, Minneapolis, MN) which is inserted through the skin into the vein under ultrasound guidance. Insertion can be done directly using the stylet or using a Seldinger technique over a 0.035-inch wire. Impedance values can be measured to confirm placement and are typically between 150 and 350 Ω [3, 15]. Additional local anesthesia is used to infiltrate the tissue surrounding the stylet, the patient is then placed in trendelenburg, and treatment is initiated with the stylet placed 2–3 mm away from the deep venous system. The treatment of perforators uses a spot-welding technique where all four quadrants of the venous wall in the location of the tip of the stylet are treated for 60 s each. The stylet is then withdrawn 3–5 mm, and a second treatment is performed in the same manner. This was repeated for the length of the perforator. At the completion of the treatment, compression is applied to the treated area.

For laser treatment of perforators, a 1470-nm, 400-μm laser fiber can be used. Intraluminal access is obtained with a micropuncture needle kit using ultrasound guidance. Once the fiber is positioned, typically at or just below the level of the fascia and at 2–3 mm away from the deep venous system, local anesthetic is infiltrated into the surrounding tissues and treatment begins. The vein is treated using a pulsed technique with the generator set at 6 W, and the vein was treated with 50–100 J per 2-mm segments for the length of the perforator. At the conclusion of the laser treatment, the probe is removed, and compression therapy is applied to the site.

Ultrasound-Guided Foam Sclerotherapy

Foam sclerotherapy is a fast and relatively simple method for ablating pathologic perforating veins. It utilizes a sclerosant, typically sodium tetradecyl

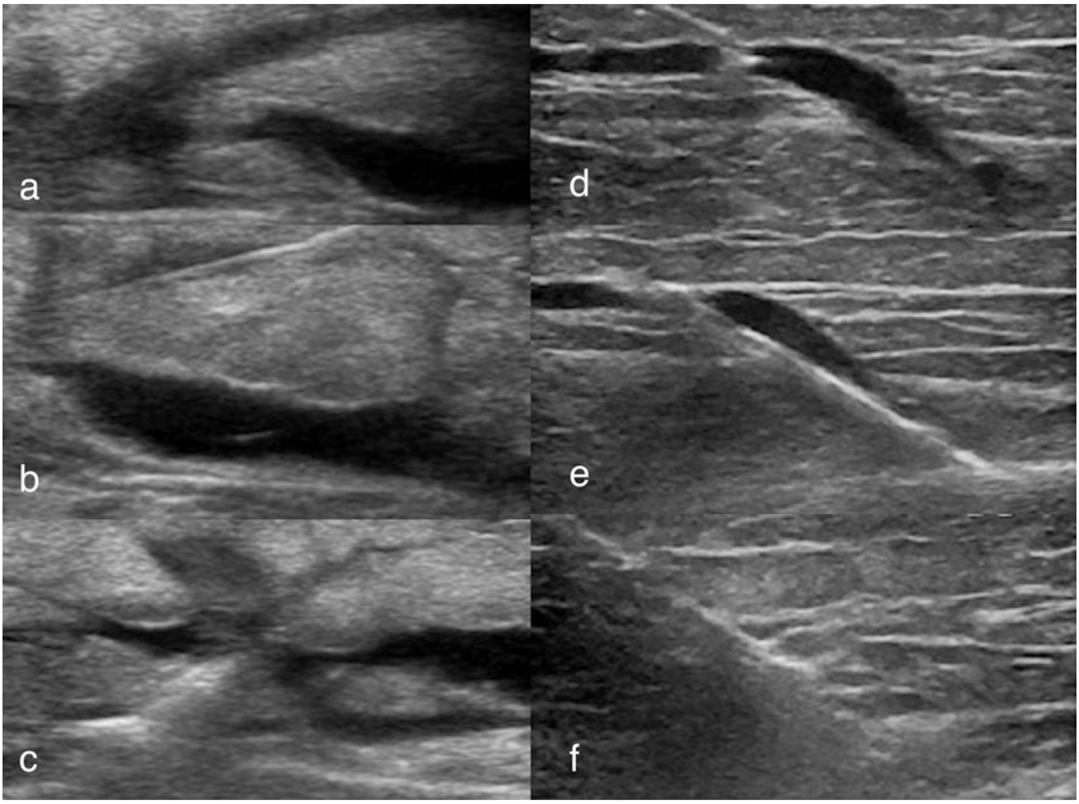

Fig. 13.1 Endovenous thermal ablation of perforators. (**a**) Duplex image showing the perforating vein before EVLT; (**b**) The EVLA fiber placed into the perforator at the level of the fascia; (**c**) duplex showing successful post-procedure ablation; (**d**) A duplex image showing the perforating vein before RFA; (**e**) The RFA images showing access of the stylet; (**f**) duplex showing successful post-procedure ablation

sulfate (STS) or polidocanol, to chemically ablate the vein. Tessari et al. describe a technique using a three-way stopcock for mixing and injecting, and this technique has been widely adopted despite lack of approval by the FDA. The technique uses two syringes connected to a stopcock, one with 1 part sclerosant and the other one with 4 parts air. The two syringes are agitated rapidly until a uniform size microbubble is formed [25].

Ultrasound is used to identify the IPV and its associated varicosities. A 25- or 30-gauge needle is typically used for cannulation of the varicosities to allow a larger volume of sclerosant to be injected. Once access is achieved, the foam is created and slowly injected. The foam is echogenic and easily visualized with duplex. Care should be taken to avoid injecting foam into the deep system. This is achieved by applying compression to the junction between the deep vein and IPV using the ultrasound probe. This allows the foam to reflux into the connecting varicosities and ablate the venous plexus. During the injection, the leg is elevated to reduce the amount of sclerosant entering the deep system. After treatment, compression is applied over the treated perforator (Fig. 13.2).

Current Data

At present, there is no compelling level 1 evidence to support the treatment of IPVs in venous ulcer healing or recurrence [15]. There are a number of small series and retrospective analysis that advocate for IPV ablation in C5 and C6 disease. One of the first studies looking at the

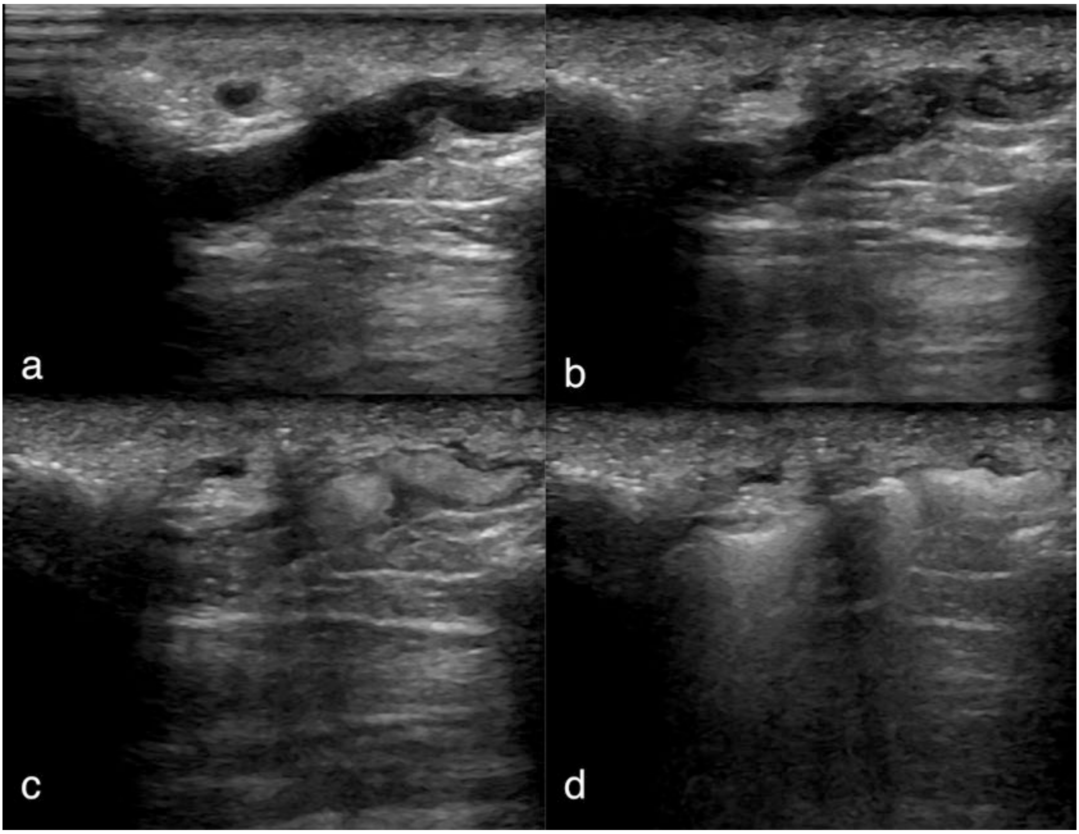

Fig. 13.2 Ultrasound-guided foam sclerotherapy of a perforator vein. (**a**) Perforator vein prior to injection. (**b**) Visualization of the sclerosant within the vein. (**c**) Partial thrombosis of the perforator vein. (**d**) Complete filling of the IPV

efficacy of EVLA in treating IPVs was published in 2010 by Hissink et al. [26]. They prospectively evaluated 58 patients with advance venous disease (C4–C6) that were successfully treated with EVLA with concomitant treatment of refluxing axial veins. They demonstrated that 80% of the ulcers healed with no major complications. Dumantepe et al. demonstrated successful 12-month closure rates approaching 90% with associated improvement in venous clinical severity score [27]. More recently, Zerweck and colleagues reported treatments of 69 IPVs concomitantly with great or small saphenous ablation with a success rate at 30 days of 96% with no reported complications [28]. In 2009, Hingorani et al. published their experience with RFA of IPVs. Their initial success rate was 88% (37 of 43), and they identified venous pulsatility as an independent risk factor for treatment failure in the cohort. Interestingly, the patients with venous pulsatility had only a 20% ablation rate [29].

In one of the larger series, Lawrence et al. enrolled 208 patients with CEAP 6 disease between 2007 and 2010 and looked at the healing of ulcers as an endpoint. All patients enrolled were treated with compression and ablation of axial veins, and after 3 months of aggressive wound care and compression, if the ulcers fail to heal, then perforator incompetence was investigated and treated with endovenous thermal ablation. Forty-five patients in this study met criteria and underwent IPV ablation. Ulcer healing was achieved in 71% at a mean of 193 days.

At 13 months, there was a 4% recurrence rate in this cohort. Interestingly, no ulcers healed without the ablation of at least one incompetent perforator [5]. Even though this study is not a randomized prospective study, it does demonstrate the existence of a subgroup of patients with ulcers that will fail to heal even with optimal compression and ablation of refluxing axial veins, and hence may benefit from perforator ablation. Harlander-Locke and colleagues looked to quantify the rate of healing using planimetry software. They demonstrated an improvement in ulcer healing rate following ablation of refluxing axial veins and perforator veins. Technical success in perforator closure was seen in 81.8%, with 76.3% of ulcers healing at a mean of 142 days. Their recurrence was 7.1% at a mean of 12-month follow-up [30]. In 2015, Shi et al. looked retrospectively at a group of 300 patients with incompetent perforator veins associated with different CEAP classes, half of which underwent ablation of the IPVs, and all of which underwent treatment of refluxing axial veins. At 1 year, 81.3% of EVLT-treated IPVs remained closed. At 1 year, 93% ulcers in the EVLT-treated IPV group healed compared to 89.8% ulcers in the untreated IPV group. Although this result is not statistically significant, the group did find that the median ulcer healing time was significantly shortened in the EVLT-treated IPV group from 3.3 to 1.4 months [31]. Masuda et al. identified and treated 80 limbs with incompetent perforator veins with ultrasound-guided sclerotherapy and reported 86.5% of ulcers healed at a mean time of 36 days. Although his ulcer recurrence rate was high at 32% with a mean of 20 months, he was able to demonstrate a statistically significant association between recurrence of ulcer and recurrence of incompetent perforators [32]. A more recent study by Kiguchi et al. showed a 54% thrombosis rate per injection in patients with venous ulceration. The patients that were successfully treated had significant improvement in ulcer healing rates (69 vs. 38% $P < 0.001$) [33]. There is currently no consensus as to the best modality to ablate IPVs because there are very few comparative studies. In 2016, Hager and colleagues published a comparative analysis between the three modalities in an effort to identify risk factors for treatment failure. They reported the results of 296 ablation procedures in 112 patients, two thirds of which suffered C5–C6 disease. Of the 296 ablations, 21% underwent RFA, 31% underwent EVLA, and the remainder underwent UGFS. They concluded that RFA was the most reliable means of closure, with 73% at 2 weeks. Closure rates were significantly lower for UGFS at 57% but improved to 85% (EVLA) or 90% (RFA) with a subsequent thermal ablation [3].

Complications

The complications of treating incompetent perforating veins are modality specific and similar to known ones previously described for the treatment of refluxing axial veins. Common complications such as paresthesia, discoloration, ecchymosis, thrombophlebitis, and pain can be seen in all three modalities [34]. Thermal burns were associated with RFA and EVLA, while TIAs or visual disturbances were more specifically seen with sclerotherapy [15]. Serious complications such as death and pulmonary embolism occur in less than 1%, as demonstrated by a systematic review of 9000 patients undergoing sclerotherapy [35]. In current literature, 1–2% had paresthesia, 1–2% had thrombophlebitis, <1% had skin discoloration, and 1–25% had pain. Although ecchymosis was included by some studies as a complication with an occurrence as high as 70%, most studies did not consider it to be a complication. More rarely were skin necrosis seen in <2% and DVTs seen in 1–5% [3, 26–28, 31, 32, 36, 37].

Conclusions

The treatment of IPVs has been shown to improve venous ulcer healing rates and reduce ulcer recurrence. A proposed algorithm for the treatment of

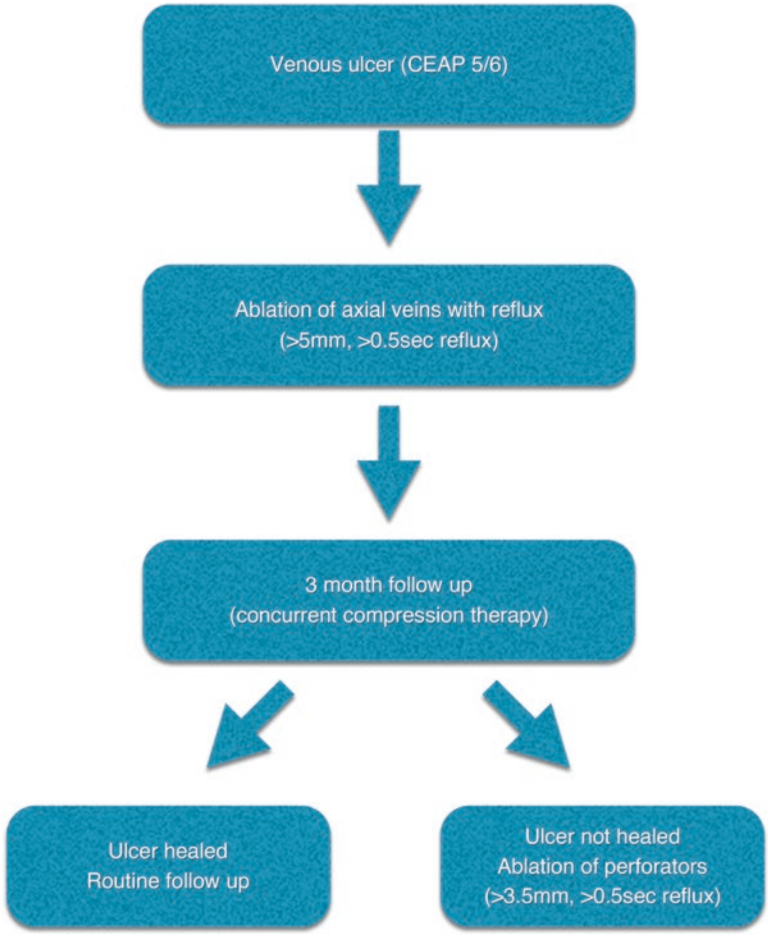

Fig. 13.3 Treatment algorithm for advanced venous insufficiency

advanced venous disease is depicted in Fig. 13.3. In modern clinical practice, the three modalities most often used are UGFS, RFA, and EVLA. These have been shown to be safe and effective although there are very few studies that compare the techniques. Venous pulsatility has been shown to lead to treatment failure in several studies, as it is typically a surrogate marker for fluid overload and severe venous hypertension [29]. Hager et al. also identified BMI >50 as a predictor of failure among all the modalities; anticoagulation and age were not significant predictors [3]. Future studies will seek to identify other risk factors for treatment failure and attempt to establish an algorithm to best treat IPVs given a patient's anatomy and comorbidities.

References

1. Kaplan RM, Criqui MH, Denenberg JO, Bergan J, Fronen A. Quality of life in patients with chronic venous disease: San Diego population study. J Vasc Surg. 2003;37:1047–53.
2. Smith JJ, Guest MG, Greenhalgh RM, Davies AH. Measuring the quality of life in patients with venous ulcers. J Vasc Surg. 2000;31:642–9.
3. Hager ES, Washington C, Steinmetz A, Wu T, Singh M, Dillavou E. Factors that influence perforator vein closure rates using radiofrequency ablation, laser ablation, or foam sclerotherapy. J Vasc Surg Venous Lymphat Disord. 2016;4(1):51–6.
4. Eberhardt RT, Affetto JD. Chronic venous insufficiency. Circulation. 2005;111:2398–409.
5. Lawrence PF, Alktaifi A, Rigberg D, DeRubertis B, Gelabert H, Jimenez JC. Endovenous ablation

of incompetent perforating veins is effective treatment for recalcitrant venous ulcers. J Vasc Surg. 2011;54(3):737–42.
6. Mozes G, Gloviczki P, Menawat SS, Fisher DR, Carmichael SW, Kadar A. Surgical anatomy for endoscopic subfascial division of perforating veins. J Vasc Surg. 1996;24:800–8.
7. Linton RR. The communicating veins of the lower leg and the operative technic for their ligation. Ann Surg. 1938;107:582–93.
8. Dodd H. The diagnosis and ligation of incompetent ankle perforating veins. Ann R Coll Surg Engl. 1964;34:186–96.
9. Ananthakrishnan N, Parkash S, Banerjee SN. A new technique for chronic venous ulcers of the lower limb: modified Felder-Rob procedure. ANZ J Surg. 1989;59(2):157–60.
10. De Palma RG, Kowallek DL, Barcia TC. New approaches to an old and vexing problem; improving the results of SEPS: an overview. Acta Chir Belg. 2000;100(3):100–3.
11. Hauer G, Barken J, Wisser I, Deiler S. Endoscopic subfascial dissection of perforating veins. Surg Endosc. 1988;2:5–12.
12. Bergan JJ, Murray J, Greason K. Subfascial endoscopic perforator vein surgery: a preliminary report. Ann Vasc Surg. 1996;10:211–9.
13. Gloviczki P, Bergan JJ, Rhodes JM, Canton LG, Harmsen S, Ilstrup DM, et al. 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;29:489–502.
14. Wittens CH, Pierik RG, van Urk H. The surgical treatment of incompetent perforating veins. Eur J Vasc Endovasc Surg. 1995;9:19–23.
15. Gloviczki P, Comerota AJ, Dalsing MC, Eklof BF, Gillespie DL, Gloviczki ML, Lohr JM, McLafferty RB, et al. The care of patients with varicose veins and associated chronic venous diseases: clinical practice guidelines of the Society for Vascular Surgery and the American Venous Forum. J Vasc Surg. 2011;53(5):2S–48S.
16. Gloviczki P. Handbook of venous disorders: guidelines of the American Venous Forum. 3rd ed. London: Hotter Arnold; 2009. p. 348–58.
17. Mayberry JC, Moneta GL, Taylor LM Jr, Porter JM. Fifteen-year results of ambulatory compression therapy for chronic venous ulcers. Surgery. 1991;109:575–81.
18. Michaels JA, Brazier JE, Campbell WB, MacIntyre JB, Palfreyman SJ, Ratcliffe J. Randomized clinical trial comparing surgery with conservative treatment for uncomplicated varicose veins. Br J Surg. 2006;93:175–81.
19. van Gent WB, Catarinella FS, Lam YL, Nieman FH, Toonder IM, van der Ham AC, Wittens CH. Conservative versus surgical treatment of venous leg ulcers: 10-year follow up of a randomized, multicenter trial. Phlebology. 2015;30(1 Suppl):35–41.
20. Kabnick LS. Varicose veins: endovenous treatment. In: Cronenwett JL, Johnston KW, editors. Rutherford's vascular surgery. 7th ed. Philadephia: Saunders; 2010. p. 871–88.
21. Felice ED. Shedding light: laser physics and mechanism of action. Phlebology. 2010;25:11–28.
22. Bone C. Tratamiento endoluminal de las varices con laser de diodo: estudio preliminary. Rev Patol Vasc. 1999;5:35–46.
23. Chandler JG, Pichot G, Sessa CS, Schuller-Petrovic S, Kabnick LS, Bergan JJ. Treatment of primary venous insufficiency by endovenous saphenous-vein obliteration. Vasc Surg. 2000;34:201–13.
24. Proebstle TM, Vago B, Alm J, Gockeritz O, Lenard C, Pinchot O, et al. Treatment of the incompetent great saphenous vein by endovenous radio frequency powered segmental thermal ablation: first clinical experience. J Vasc Surg. 2008;47:151–6.
25. Tessari L, Cavezzi A, Frullini A. Preliminary experience with a new sclerosing foam in the treatment of varicose veins. Dermatol Surg. 2001;27:58–60.
26. Hissink RJ, Bruins RM, Erkens R, Castellanos Nuijts ML, van den Berg M. Innovative treatments in chronic venous insufficiency: endovenous laser ablation of perforating veins: a prospective short-term analysis of 58 cases. J Vasc Endovasc Surg. 2010;40(3):403–6.
27. Dumantepe M, Tarhan A, Yurdakul I, Ozler A. Endovenous laswer ablation of incompetent perforating veins with 1470 nm, 400 μm radial fiber. Photomed Laser Surg. 2012;30(11):672–7.
28. Zerweck C, von Rodenberg E, Knittel M, Zeller T, Schwarz T. Endovenous laser ablation of varicose perforating veins with the 1470-nm diode laser using the radial fibre slim. Phlebology. 2014;29(1):30–6.
29. Hingorani AP, Ascher E, Marks N, Shiferson A, Patel N, Goal K, Jacob T. Predictive factors of success following radio-frequency stylet (RFS) ablation of incompetent perforating veins (IPV). J Vasc Surg. 2009;50(4):844–8.
30. Harlander-Locke M, Lawrence PF, Alktaifi A, Jimenez JC, Rigberg D, DeRubertis B. The impact of ablation of incompetent superficial and perforator veins on ulcer healing rates. J Vasc Surg. 2012;55(2):458–64.
31. Shi H, Liu X, Lu M, Lu X, Jiang M, Yin M. The effect of Endovenous laser ablation of incompetent perforating veins and the great saphenous vein in patients with primary venous disease. Eur J Vasc Endovasc Surg. 2015;49(5):574–80.
32. Masuda EM, Kessler DM, Lurie F, Puggioni A, Kistner RL, Eklof B, et al. The effect of ultrasound-guided sclerotherapy of incompetent perforator veins on venous clinical severity and disability scores. J Vasc Surg. 2006;43:551–6.
33. Kiguchi MM, Hager ES, Winger DG, Hirsch SA, Chaer RA, Dillavou ED. Factors that influence per-

forator thrombosis and predict healing with perforator sclerotherapy for venous ulceration without axial reflux. J Vasc Surg. 2014;59(5):1368–76.
34. O'Donnell TF. The role of perforators in chronic venous insufficiency. Phlebology. 2010;25:3–10.
35. Jia X, Mowatt G, Burr JM, Cassar K, Cook J, Fraser C. Systematic review of foam sclerotherapy for varicose veins. Br J Surg. 2007;94:925–36.
36. Boersma D, Smulders DL, Bakker OJ, van den Haak RF, Verhoeven BA, Koning OH. Endovenous laser ablation of insufficient perforating veins: energy is key to success. Vascular. 2014;24(2):144–9.
37. 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;31:123–8.