How I Decide to Ablate a Refluxing Perforator

A review of the evidence and rationale for perforator vein ablation in venous disease management.

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Incompetent perforator veins (IPVs) are frequently encountered in the evaluation of the patient with venous insufficiency. The advent of percutaneous thermal and chemical ablation methods has made perforator closure a relatively simple and low-risk office procedure, but patient selection can be confusing given the lack of high-level clinical data proving the clinical benefit of perforator treatment. The goal of this article is to summarize a body of information that may assist the vein practitioner in developing an informed and practical approach to managing incompetent perforators.

ANATOMY AND NOMENCLATURE

Based upon anatomic studies, the human lower extremity contains, on average, > 60 perforator veins that function as links between the deep and superficial venous systems. Although sometimes conceptualized as a solitary venous channel, the perforator canal contains a complex of vessels as demonstrated by Haruta et al, who performed endoscopic adventitial dissection on 128 perforators in 50 limbs to confirm the number and type of vessels present.[1] In this series, 88.2% of perforator veins studied traveled with a perforator artery, with the most common vascular pattern being one perforator artery combined with one normal and one incompetent perforator vein (38%), followed by one perforator artery combined with two incompetent perforator veins (30%). An isolated incompetent perforator vein without an identified artery was the pattern in 25%.[1] Perforators have valves, and normal flow within a functional perforator is predominantly in the superficial to deep direction although there is bidirectionality of flow related to muscular pump function.[2] Perforators are also categorized as direct and indirect, with direct perforators emptying into axial deep veins and indirect perforators emptying into calf venous sinuses.[3]

In 2002, the International Consensus Committee published an update on nomenclature of veins of the lower extremity including renaming perforators according to anatomically descriptive terminology. The accepted current nomenclature for perforator veins is presented in Table 1 with correlation to historical eponyms that are now retired from use.[4-6]

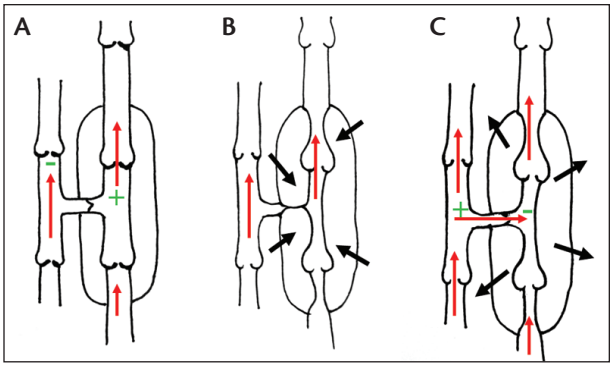

Figure 1. Schematic representation of normal perforator function. Plus and minus signs denote relative pressure differential between deep and superficial systems. Red arrows denote flow direction, superficial vein is on the left, deep vein on the right in each image. A) Resting phase of pump cycle: blood is filling the deep veins, and deep venous pressure is increasing. B) Contraction phase: muscular compression (black arrows) of the deep veins empties the veins and closes the fascial gate preventing excess retrograde perforator flow. C) Early relaxation phase: muscles relax (black arrows) causing relative low pressure in the deep system promoting flow from superficial to deep direction.

PERFORATOR FUNCTION: NORMAL

The perforator system functions primarily to divert venous drainage from the skin and superficial tissues to the deep veins. During contraction of the calf and thigh muscular pumps, the compression of the deep veins results in increased venous pressure that closes the perforator valve. The perforator canal is also centrally cuffed by muscular fibers and connective tissue (a "fascial gate") that constricts

TABLE 1. CURRENT AND HISTORICAL NOMENCLATURE OF THE PERFORATING VEINS OF THE LOWER EXTREMITY[4,6]

Location	Current Nomenclature	Eponym
Foot perforators	Dorsal foot PV Medial foot PV Lateral foot PV Plantar foot PV	
Ankle perforators	Medial ankle PV Anterior ankle PV Lateral ankle PV	May's or Kuster's
Leg perforators	Medial leg PV: Paratibial PV Posterior tibial PV Anterior leg PV Lateral leg PV Posterior leg PV: Medial gastrocnemius PV Lateral gastrocnemius PV Intergemellar PV Para-Achillean PV	Boyd's, Sherman's, 24 cm Cockett's I, II, III
Knee perforators	Medial knee PV Suprapetellar PV Lateral knee PV Infrapatellar PV Popliteal fossa PV	
Thigh perforators	Medial thigh PV: PV of the femoral canal Inguinal PV Anterior thigh PV Lateral thigh PV Posterior thigh PV: Posteromedial PV Sciatic PV Posterolateral PV Pudendal PV	Hunter's, Dodd's
Gluteal perforators	Superior gluteal PV Midgluteal PV Lower gluteal PV	

Abbreviation: PV, perforator vein.

during muscular contraction, thus also assisting in preventing retrograde flow. During the muscular relaxation phase, the empty deep veins re-expand, fascial gates relax, and venous pressure decreases promoting passive flow of blood from the superficial system through the perforators to the deep veins. As the deep venous pressure again rises, there is brief reversal of flow in the perforator until the perforator valve again closes and the cycle repeats. Because cyclical bidirectional flow is a normal characteristic of perforators, the term "incompetent" can be misleading when applied to perforator retrograde flow, and *pathologic* versus *normal* may be useful alternative descriptors of perforator function. Figure 1 illustrates normal perforator function.

PERFORATOR FUNCTION: PATHOLOGIC

Perforator dysfunction is characterized by dilatation with valvular incompetence and retrograde flow. In his original landmark publication on the definition of normal retrograde flow limits in lower extremity veins, Labropoulos defined 350 milliseconds of retrograde flow as the upper limit of normal in a perforator vein.[7] This has since been slightly modified in clinical practice, and the Society for Vascular Surgery/American Venous Forum (SVS/AVF) clinical practice guidelines for care of patients with chronic venous disease currently defines a pathologic perforator as having a diameter of ≥ 3.5 mm and ≥ 500 milliseconds of retrograde flow. These guidelines also include perforator location under a healed or active ulcer as a pathological criteria.[8] Sonographic appearance of a pathological perforator is shown in Figure 2.

There are two main mechanisms by which a perforator may become incompetent. In the antegrade overload pattern, retrograde flow in a superficial varicosity decompresses through a re-entry perforator resulting in perforator dilatation and eventual valvular incompetence. In a severe case, the excess venous load may secondarily cause distension and reflux in the deep veins as well (Figure 3). In the retrograde blow-out pattern, the presence of chronic deep venous hypertension stresses the perforator from a retrograde direction causing perforator dilatation, valvular incompetency, and secondary superficial

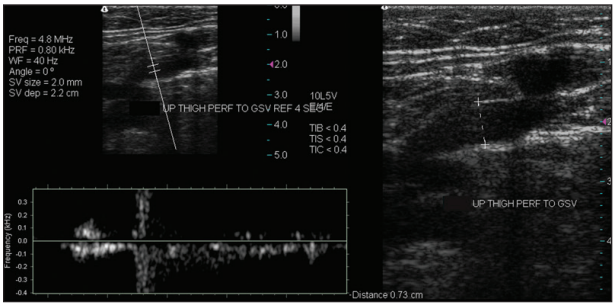

Figure 2. Ultrasound images of a dilated and incompetent pathologic perforator vein. Pulsed wave Doppler demonstrates 3 to 4 seconds of retrograde flow after calf compression (left), and the perforator diameter is markedly dilated at 7.3 mm (right).

venous hypertension manifesting as varicose veins and inflammatory changes. This pattern typically presents in patients with postthrombotic obstruction or severe deep venous reflux (Figure 4).

These two mechanisms of perforator dysfunction explain why some incompetent perforators spontaneously improve with correction of superficial venous reflux but others do not. If an incompetent perforator results from antegrade overload, correction of the superficial reflux alone is often sufficient to normalize perforator hemodynamics and permit return to normal function. However, if the perforator incompetence develops secondarily to uncorrectable deep venous hypertension, eliminating the associated superficial venous reflux does not address the underlying cause of the problem, the perforator cannot recover normal function, and active intervention may be needed. In his study of functional anatomy of incompetent perforators in 505 limbs with suspected chronic venous disease, Delis noted that IPVs in CEAP class 1 to 3 limbs were more likely to be associated with only superficial venous reflux (the antegrade overload pattern), while IPVs in more diseased limbs (CEAP class 4–6) were significantly more likely to be associated with both superficial and deep venous reflux (retrograde blow-out pattern).[9]

METHODS OF PERFORATOR CLOSURE

Open surgical perforator ligation (Linton procedure) has been replaced in practice by less invasive methods of IPV closure including subfascial endoscopic perforating vein surgery (SEPS), endovenous thermal ablation with laser or radiofrequency, and ultrasound-guided sclerotherapy. Recently, intravascular adhesive for perforator closure has been reported in a feasibility study.[10] In 2004, Tenbrook et al conducted a meta-analysis of published data on SEPS for venous ulcer treatment, including one randomized controlled trial (RCT) and 19 case series for

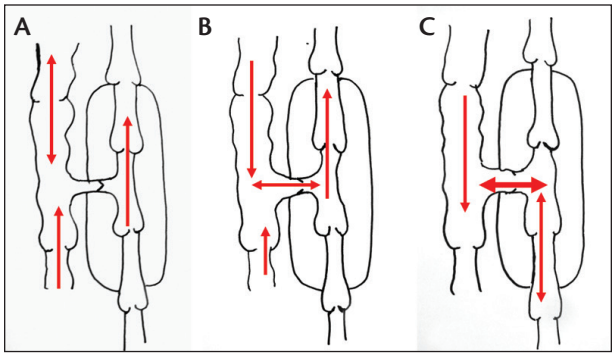

Figure 3. Schematic representation of overload mechanism of perforator incompetence. Red arrows denote flow direction, superficial vein is on the left, and deep vein is on the right of each image. A) Early reflux in the superficial vein, perforator is still competent. B) As superficial reflux increases and becomes a constant stressor, the perforator begins to dilate, and early perforator incompetence develops. C) Chronic superficial reflux into a severely dilated perforator with high-volume bidirectional flow and secondary deep venous reflux.

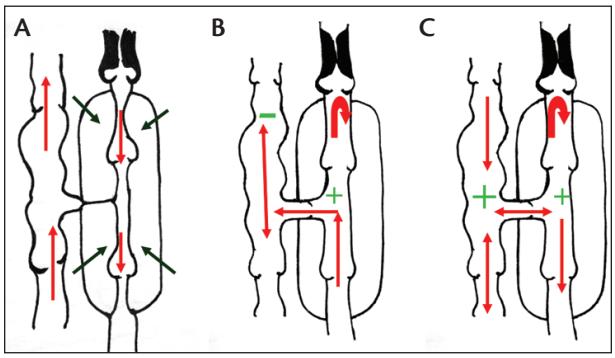

Figure 4. Schematic representation of the blow-out mechanism of perforator incompetence in setting of chronic deep venous obstruction. Red arrows denote flow direction, superficial vein is on the left, deep vein on the right of each image. Green plus and minus signs denote pressure differentials. A) Chronic deep venous obstruction during muscular contraction (black arrows): venous outflow is diverting to a dilated superficial system, but the perforator at this level is still competent. B) Chronic deep venous hypertension is causing progressive dilatation of the perforator and some incompetence. Retrograde flow into the already overworked superficial system causes further superficial vein distension and worsening reflux. C) Complete perforator incompetence after long-standing strain, further overload of the superficial vein, which is now also severely incompetent. Retrograde flow from above, antegrade flow from below, and retrograde flow from the IPV combine to create a focal point of severe superficial venous hypertension at the junction of the superficial and perforator veins.

a total of 1,140 treated limbs, 526 of which had open ulcers at the time of SEPS, and 70% of which had CEAP class 5 to 6 disease at time of treatment.[11] This meta-analysis reported overall rates of ulcer healing rate of 88% and ulcer recurrence of 13% after SEPS, with a low rate of complications (1% DVT, 6% wound infection, 7% paresthesia), comparing favorably to outcomes of both open surgical ligation and compression therapy alone.

In recent years, the use of SEPS has declined in favor of even less invasive methods for percutaneous ablation of perforators (PAPs). Indeed, the SVS/AVF clinical practice guidelines for management of venous leg ulcers recommends that PAPs be performed preferably over open surgical techniques to avoid incisions in the compromised tissue of the ulcer bed.[12] PAPs has been successfully done with ultrasound guidance using laser, radiofrequency, and sclerosants. A detailed discussion of these treatments is beyond the scope of this article, but small clinical series and observational studies have demonstrated 90% to 100% initial closure rates with recanalization rates in the 10% to 20% range. Complications, which are rare, include nerve or skin injury, phlebitis, AV fistulae, and DVT. PAPs have the theoretical advantages of requiring only local anesthesia, minimal access site incisions, being applicable to perimalleolar perforators that are difficult to treat surgically, and being an easily repeated treatment in the event of recurrent or new incompetent perforators.[13-16] Ultrasound-guided sclerotherapy of an IPV is shown is Figure 5.

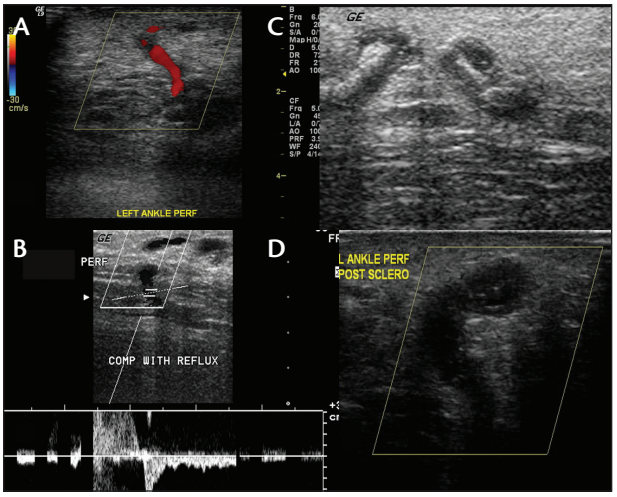

Figure 5. Sonographic images of a posterior tibial IPV undergoing sclerotherapy. A) Color flow image showing retrograde flow in the IPV. B) Pulsed wave Doppler confirming 2 seconds of retrograde flow. C) Foamed 3% sodium tetradecyl sulfate was injected under ultrasound guidance, access point for injection in the adjacent varicose vein to avoid inadvertent injection of the perforator artery. D) Two weeks after treatment, ultrasound confirmed perforator occlusion with no color flow.

THE ROLE OF PERFORATORS IN CHRONIC VENOUS INSUFFICIENCY

IPVs have long been suspected to contribute to the pathophysiology of chronic venous insufficiency, but the exact role they play remains incompletely defined. Studies do indicate an association between perforator incompetence and increased severity of venous disease. Labropoulos et al demonstrated a 28% prevalence of IPVs in the presence of chronic venous disease compared to 0% in normal controls. He also noted significantly increased perforator diameter in CEAP class 4 to 6 limbs compared to controls.[17] Delis et al studied the in situ hemodynamics of perforator veins, stratifying and comparing IPVs in CEAP class 1 to 2 versus class 3 to 6 subjects. He found statistically significantly increased IPV flow volume and velocities in patients with more severe clinical disease.[18]

However, although IPVs increase in number and worsen in severity as venous disease severity increases, there is a deficiency of data conclusively proving that IPVs play a causal role in venous insufficiency, or that treating them promotes ulcer healing or limits ulcer recurrence. Investigation of this question has been confounded by two factors. First, isolated perforator insufficiency is rare in venous ulcer patients, seen only in 3.2%,[19] and therefore difficult to evaluate without confounding bias from venous pathology elsewhere in the limb. Second, most studies on venous treatments incorporating perforator interruption fail to isolate the perforator intervention from other concomitant venous treatments such as saphenous vein ablation, thus rendering analysis of the perforator contribution to treatment response difficult or impossible.

RCTs have demonstrated that correction of superficial venous reflux (with or without perforator treatment) does not augment primary ulcer healing but does decrease the rate of ulcer recurrence compared to compression therapy alone. The ESCHAR study[20] randomized 500 patients to saphenous vein stripping with compression therapy versus compression therapy alone, with only 3.1% including treatment of perforators. This study demonstrated no difference between ulcer healing rates between the two groups at 24 weeks, but a statistically significant reduction in ulcer recurrence at 1 year to 14%, compared to 28% in the compression only cohort. This positive benefit in the absence of perforator treatment threw doubt on the role of IPVs as a primary cause of venous ulceration. Van Gent et al attempted to evaluate perforator treatment in an RCT comparing subfascial endoscopic surgical ligation (SEPS) with compression to compression alone for treatment of venous ulcers.[21]

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However, assessment of SEPS was confounded by the fact that concomitant saphenous surgery was allowed, and of the 91 subjects who underwent SEPS, 51 also had superficial vein surgery, 29 had a history of prior superficial vein surgery in the past, and only 11 underwent SEPS alone. This study did not show significant difference in ulcer healing or recurrence between the two groups. However, in a subsequent publication, the investigators reexamined the data from the perspective of completed SEPS procedures (45%) versus incomplete SEPS (55%) in which IPVs were missed as detected on postoperative duplex ultrasound. They found no difference in ulcer healing, but noted a significantly higher ulcer recurrence rate in patients with incomplete SEPS, implicating residual IPVs as active contributors to the venous pathophysiology.[22]

Despite the lack of level 1 randomized data, well-constructed prospective observational studies do exist to support the IPV closure in patients with advanced venous disease. Lawrence et al reported results of RFA of incompetent perforators in subjects with refractory ulcers of > 3 months' duration. With intent to isolate the perforator issue, subjects were included only if saphenous reflux was absent, or previously treated. The subjects were recruited from the institution's wound care center, and all had a minimum of 3 months (mean 34 months) dedicated wound care including multilayer compression therapy supported by debridement, skin substitutes, topical growth factors, and antibiotic therapy prior to undergoing perforator ablation. In this series, 75 ulcers with 86 IPVs were treated, with a perforator closure rate of 71% including repeat ablation of some IPVs that failed initial attempt. Eighty of the 86 refractory ulcers healed (93%), and no ulcer healed without at least one perforator being closed, strongly suggesting that perforator reflux contributes to the pathological state.[23]

Masuda et al evaluated ultrasound-guided liquid sclerotherapy of IPVs on venous clinical severity and venous disability scores. To isolate the perforator issue, patients who had undergone surgery for venous disease within the previous 2 years were excluded. Eighty limbs were treated with CEAP clinical class 2 to 6 disease, 46% (37 limbs) of whom were class 6. The authors report 98% perforator occlusion rate with 75% persistent occlusion on follow-up (mean, 20 months). There was significant improvement in the venous clinical severity and venous disability scores of subjects in clinical classes 4 to 6 after treatment. In the ulcer subcohort, 67.6% healed the ulcer after one treatment, 13.5% failed to heal after multiple treatments, and recurrent perforators (recanalized treated IPVs) and postthrombotic syndrome were significant risk factors for ulcer recurrence.[13]

TREATMENT APPROACH

When considering whether to intervene on a refluxing perforator, the following points merit systematic consideration:

1. Confirm that the perforator meets pathological anatomic criteria:
   a. ≥ 3.5 mm diameter, ≥ 500 msec retrograde flow:
      • *Consider for treatment*
2. Consider the perforator in the context of overall disease presentation:
   a. Is it associated with edema, inflammation or ulceration and
      i. With other correctable sources of reflux:
         • *Address other reflux first, reassess patient clinical status and perforator after 4 to 6 weeks. If no significant improvement, treat perforator.*
      ii. Without other correctable sources of reflux:
         • *Treat perforator*
   b. Is it associated with a varicose vein complex in which it is:
      i. The re-entry point to deep system:
         • *Treat superficial varicosities, not perforator*
      ii. The highest point of reflux:
         • *Treat perforator*

Due to the paucity of clinical data proving benefit, the SVS/AVF clinical practice guidelines for care of patients with venous disease recommends that perforator ablation be performed for pathologic perforating veins underlying healed or active ulcers (2B), and recommends against selective treatment of perforating incompetence in CEAP clinical C2 varicose veins (1B).[8]

CONCLUSION

Perforator veins serve an important function in maintaining the hemodynamic balance between the superficial and deep venous systems of the leg. Preservation of normal—as well as pathologic, but recoverable perforators—should be a goal of venous disease management. Based on current data, perforators appear less likely to be a primary

cause of venous insufficiency, but are intermediary conduits vulnerable to stress and damage from pathology in adjacent deep or superficial veins. Once recruited into the disease process, IPVs may play an active role in propagating and sustaining pathological venous circuits. IPVs in lower CEAP class 1 to 3 patients more likely reflect reentry overload, a process that reverses spontaneously with correction of the superficial reflux alone. In higher CEAP class 4 to 6 disease, deep venous pathology underlying permanent perforator damage is more frequently encountered. Patient selection for perforator ablation involves consideration of the target vessel in terms of anatomic derangement, position in the hemodynamic pattern, and overall clinical disease severity. Current practice guidelines support ablation of incompetent perforators in the setting of advanced venous insufficiency, and especially in the setting of venous ulceration. ■

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