Associations between flow in paratibial perforating veins and great saphenous vein patterns of reflux

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Abstract

Perforating veins contribute to chronic venous valvular insufficiency (CVVI, subset of CVI) of lower extremities (LE). We investigated the role of medial, proximal calf paratibial perforating veins (PTPV). Women with PTPV reflux, diameter ≥3 mm, or tortuosity were selected among 2199 LE mappings. Duplex ultrasonography (US) was performed standing. Reflux >0.5 s was abnormal. PTPV conditions were related to great saphenous vein (GSV) patterns of reflux. US of 442 LE of 379 women were analyzed, all being Clinical-Etiology-Anatomy-Pathophysiology (CEAP) classification C1, C2, and/or having intermittent, conditional swelling. Etiology was primary. Pathophysiology was reflux, not thrombosis or obstruction. Most PTPV drained (n=281, 64% of 442 or 13% of 2199), or were source (n=73, 17%/442, 3%/2199) of GSV reflux; 49 (11%/442, 2%/2199) had reflux not associated with GSV; 39 (9%/442, 2%/2199) did not have reflux. PTPV, when significative for CVVI, primarily drained-GSV reflux. PTPV was linked to reflux in 1 of 5 and was a major source of reflux in 1 of 20 legs. Detailed US of PTPV insured over 80% accuracy in CVVI mapping.

Introduction

Awareness of chronic venous valvular insufficiency (CVVI, as subset of CVI) is increasing among patients and physicians alike. Initial stages of CVVI may differ significantly among patients with telangiectasias/reticular veins, varicose veins, and intermittent swelling *versus* severe edema, skin changes or ulcers. CVVI abnormalities of great and small saphenous veins (GSV, SSV) and their tributaries have been emphasized. Our initial investigations suggested that a primary contribution of perforating veins to CVVI had low frequency.[1] Sources and drainages of saphenous veins reflux were mostly tributary, not perforating veins. As a quality control project in an International Organization for Standardization (ISO) accredited vascular laboratory, we investigated the role of medial, proximal calf paratibial perforating veins in association with early stages of CVVI. A brief review of international and personal experience follows herein to justify the focus of this laboratory data analysis.

Publications describing an international consensus emphasized, in their introductory initial sentence, *lack of precision in diagnosis*.[2,3] The *Union Internationale de Phlébologie* (UIP) consensus reports states that *Duplex ultrasound investigation has become the reference standard in assessing the morphology and hemodynamics of the lower limb veins*.[4,5] We followed the intended focus of such international perspective and investigated specifically women of a Southern Brazilian city, mostly of European descent, with early stage of CVVI. We observed that: i) GSV segmental pattern of reflux, from a proximal to a distal tributary vein, was the most common in women with telangiectasias or simple varicose veins;[1,6,7] and ii) without treatment, GSV segmental reflux became secondary to multisegmental reflux pattern.[8] We hypothesized that CVVI started at the weakest spot of vein degradation plus stress and progressed to the next weakest spot. Eventually, perforating veins and the saphenofemoral junction (SFJ) become affected. This analysis focused on perforating veins located at the proximal, medial aspect of the calf: the paratibial perforating veins (PTPV), named according to modern consensus that emphasizes an anatomic-based nomenclature.[5,9] We investigated four types of PTPV flow conditions: i) drainage of GSV reflux starting proximally; ii) source of GSV reflux in the calf; iii) abnormal reflux without association to GSV reflux; and iv) enlarged vein despite normal flow. The primary research objective was to relate these types of PTPV flow to GSV patterns of reflux. The clinical objective was to enhance awareness of the role of PTPV abnormalities on the development of CVVI. The primary statistical goal was to confirm low incidence of primary contribution of PTPV as reflux source.

Materials and Methods

This session describes: i) how the sample population entered in the study was created; ii) the basics of venous duplex ultrasonography (US) employed; iii) descriptive statistics documenting PTPV diameter, leg location, and flow patterns; and iv) the tabulations relating PTPV flow and GSV reflux patterns.

All US examinations were performed at the Angiolab, Inc. - Non-invasive Vascular Laboratory of Curitiba, state of Paraná, Brazil, an ISO accredited institution. US examinations were performed by physicians who had more than 10 years experience and passed the certification process established by a joint commission of the Brazilian societies of angiology/vascular surgery and radiology. A data base has been maintained prospectively. Retrospective analysis of GSV and PTSV patterns of reflux was performed. This project was part of protocol number 207-0084-000111 of the National Commission on Ethics of Research and approved by the Ethics Research

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Conflict of interest: CA and ALDV Engelhorn own the private Angiolab, Inc. non-invasive vascular laboratory and are Medical School Faculty; SX Salles-Cunha is a research, quality assurance consultant for Angiolab, Inc.

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Sample population

A total of 2199 lower extremity venous US examinations of 1129 women were searched for specific report of PTPV data; 1070 were bilateral and 59 were unilateral evaluations.

Exclusion criteria

- All US examinations performed in men were excluded even before the search for PTPV started and were not included in the total of examinations searched;
- Women with significant skin changes or ulcers were excluded and their examinations were not evaluated either;
- Prior GSV saphenectomy was the reason to exclude 278 of the 2199 (13%) lower extremities;
- Prior deep or superficial venous thrombosis or phlebitis was the reason to exclude 4 (0.2%) lower extremities;
- A total of 1475 (67%) lower extremities were excluded for not having a significant PTPV, either undetected or having a diameter of less than 1 mm, or having normal flow and considered not enlarged.

Inclusion criteria

- Lower extremities with PTPV either;
- Draining GSV reflux;
- Being the source of GSV reflux;
- Refluxing without being major drainage or source of GSV reflux; or
- estimated to be abnormally enlarged with diameters or approximately 3 mm or more.

A total of 442 (20% of 2199) lower extremities of 379 women entered the analysis. Bilateral *abnormal* PTPV were noted in 63 (17%/379) women. Clinical-Etiology-Anatomy-Pathophysiology (CEAP) classification was C1-telangiectasias/reticular veins, C2-varicose veins ≥3 mm in diameter, and/or C3-mostly intermittent, conditional swelling. Etiology was primary. Anatomy represented was GSV and PTPV. Pathophysiology was reflux and not thrombosis or obstruction.

Venous ultrasonography

The Angiolab CVVI US examination has been standardized for over a decade.[6-8,10-12] Once deep venous thrombosis or obstruction was ruled out, the CVVI examination was performed with the patient standing. Intermittent resting and movement minimized ill effects of standing during the testing. Siemens®, Elegra or Antares Models, were employed. Transducers centered at 7 MHz (4-9 MHz) were used to image superficial veins. Flow augmentation, forward or reverse, was forced by hand compression to have versatility, particularly in the study of perforating veins. Reflux longer than 0.5 s were considered not normal for the GSV and the PTPV.[13] In practice, reflux was longer than 1 s in the vast majority of cases.

Maps were generated to report the flow findings. Figure 1 exemplifies such mapping. The distance between a perforating vein location and the sole of the foot was measured and included in the mapping. Specific perforating vein findings included maximum potential diameter, location, flow characteristics and relationship to the GSV or other superficial or deep veins. Maximum potential diameter means actual diameter if the perforating vein was perpendicular to the fascia, or, fascial opening if the perforating vein was oblique to the fascia. PTPV flow was classified as: i) GSV reflux drainage; ii) GSV reflux source; or iii) PTPV reflux unrelated to the GSV. Figure 2 exemplifies US details commonly found in such exams. In addition, large PTPV were mentioned, usually if its diameter was ≥3 mm. Otherwise the PTPV was not mentioned in the report.

Descriptive statistics

Prevalence of: i) PTPV draining GSV reflux; ii) PTPV being a source of GSV reflux; iii) refluxing PTPV not associated with the GSV; and iv) anatomically abnormal PTPV despite normal flow were estimated.

Mean, standard deviation, minimal and maximum values were calculated for PTPV diameters and distances from the sole of the foot. PTPV flow findings were also tabulated as a function of PTPV diameters.

Comparative statistics

Comparisons of prevalence were performed using proportions on the Chi-square program available with Excel. Comparison of diameters was performed using t-test, also available with Excel.

Subgroups comparative statistics

The 4 types of PTPV flow or diameter abnormalities were cross-tabulated with the following types of GSV reflux patterns: i) segmental: reflux from a tributary or perforating vein distal to the SFJ to a tributary or perforating vein proximal to the ankle; ii) distal: reflux from a tributary or perforating vein distal to the SFJ including the GSV at the ankle level, draining into distal ankle or foot veins; iii) multi-segmental - normal SFJ: two or more refluxing segments as defined in i) or ii); iv) proximal: reflux from the SFJ to a tributary or perforating vein proximal to the ankle; v) multi-segmental - refluxing SFJ; similar to iii) but having a iv) type proximal refluxing segment; vi) diffuse: reflux from the SFJ to the ankle level; and vii)

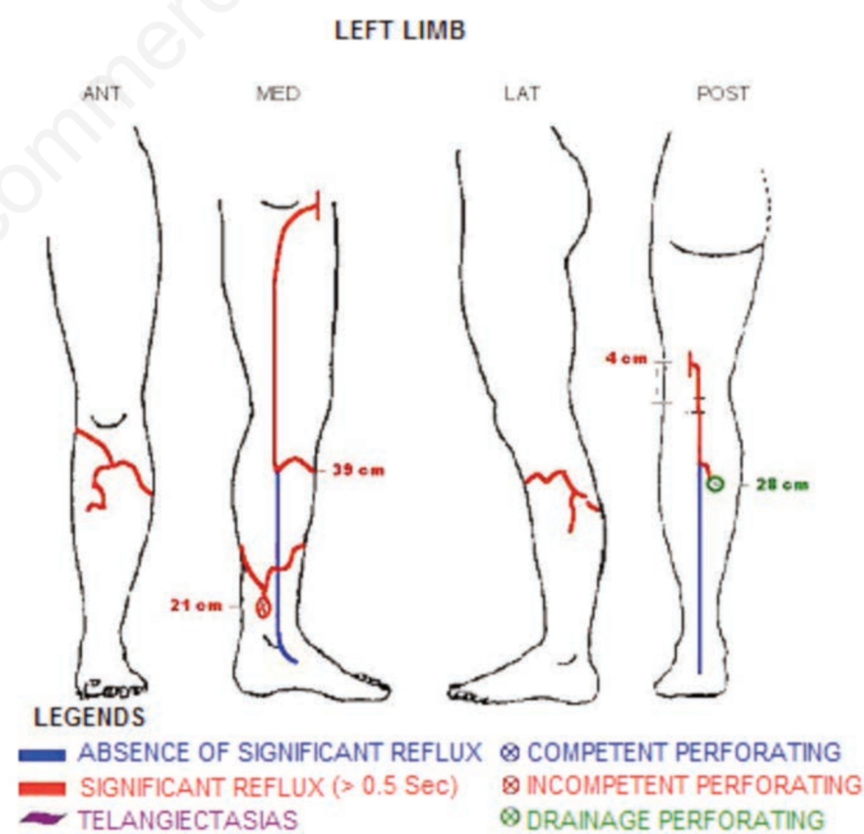

Figure 1. Example of a flow mapping diagram at Angiolab Curitiba.

non-refluxing GSV.

Perijunction reflux through the SFJ to other veins besides the GSV or through perijunction veins besides the common femoral to the GSV was not included in the analysis because such types were absent, not detected or considered not significant in the sample population studied.

Results

Prevalence of PTPV abnormal conditions are listed in Table 1. The high-to-low prevalence order was:

- PTPV as a normal vein, excluded from detailed analysis (n=1475, 67% of 2199 legs, 77% of 1917 legs studied for primary, early stage CVVI);
- PTPV as drainage point of GSV reflux (n=281, $P<0.001$);
- PTPV as source reflux (n=122): i) PTPV as source of GSV reflux (n=73); or ii) PTPV as source of non-GSV reflux (n=49); significantly less than source of GSV reflux ($P<0.01$); and
- PTPV perceived as abnormally dilated or tortuous (n=39, $P<0.001$).

Chi-square proportion analysis did not demonstrate significant difference between the right and left prevalence of PTPV abnormalities ($P>0.26$).

Average distance between the PTPV location and the sole of the foot was 31.7±3.4 (23.0-41.5) cm. Average PTPV diameter was 2.7±0.6 (1.3-7.0) mm.

Table 2 relates PTPV diameters and patterns of reflux or suspected abnormalities. All 9 veins with diameter <2 mm were draining GSV reflux. Veins in the 2 - <2.5 mm range were mostly drainage of GSV reflux also (n=96, 76%); otherwise, 90% (28/31) of the abnormal PTPV in this diameter range had reflux.

Percentage of non refluxing PTPV noted in the 3 - <3.5 mm range, 27% was higher than expected. The probability of PTPV reflux as a function of diameters were: 0% for <2 mm, 26% (103/391) for 2.0<3.5 mm, 37% (11/30) for 3.5<4.0 mm and 67% (8/12) for ≥4.0 mm. Major source of reflux (n=122, 28%/442, 6%/2199) was more prevalent in PTPV≥2.5 mm in diameter (31%, 94/306) than in smaller veins (21%, 28/136) ($P<0.03$).

Average diameters for the two subgroups representing GSV reflux source, 2.9±0.7 (2.0-7.0) mm, or PTPV reflux independent of the GSV, 2.9±0.7 (2.0-5.0) mm, were similar ($P=0.63$ by t-test). Average diameter of the combination of these two refluxing subgroups, 2.9±0.7 (2.0-7.0) mm, was significantly greater than the diameter of the GSV drainage subgroup, 2.6±0.5 (1.3-4.6) mm ($P<0.001$).

Table 3 shows the associations between PTPV flow and GSV reflux patterns. Prevalence of GSV reflux patterns were: i) segmental, 227 (51%); ii) multisegmental, 89 (20%); iii) multisegmental with refluxing SFJ, 41 (9%); iv) distal, 34 (8%); v) proximal, 28 (6%); vi) diffuse, 15 (3%); and vii) absent, 8 (2%). The SFJ had reflux - GSV diffuse, multisegmental or proximal - in 84 (19%) of the extremities. PTPV were source of segmental (45%, 33/73), multisegmental (33%, 24/73), or distal (22%, 16/73) GSV reflux.

Chi-square demonstrated that real prevalence of the subgroups was significantly different than expected subgroup prevalence

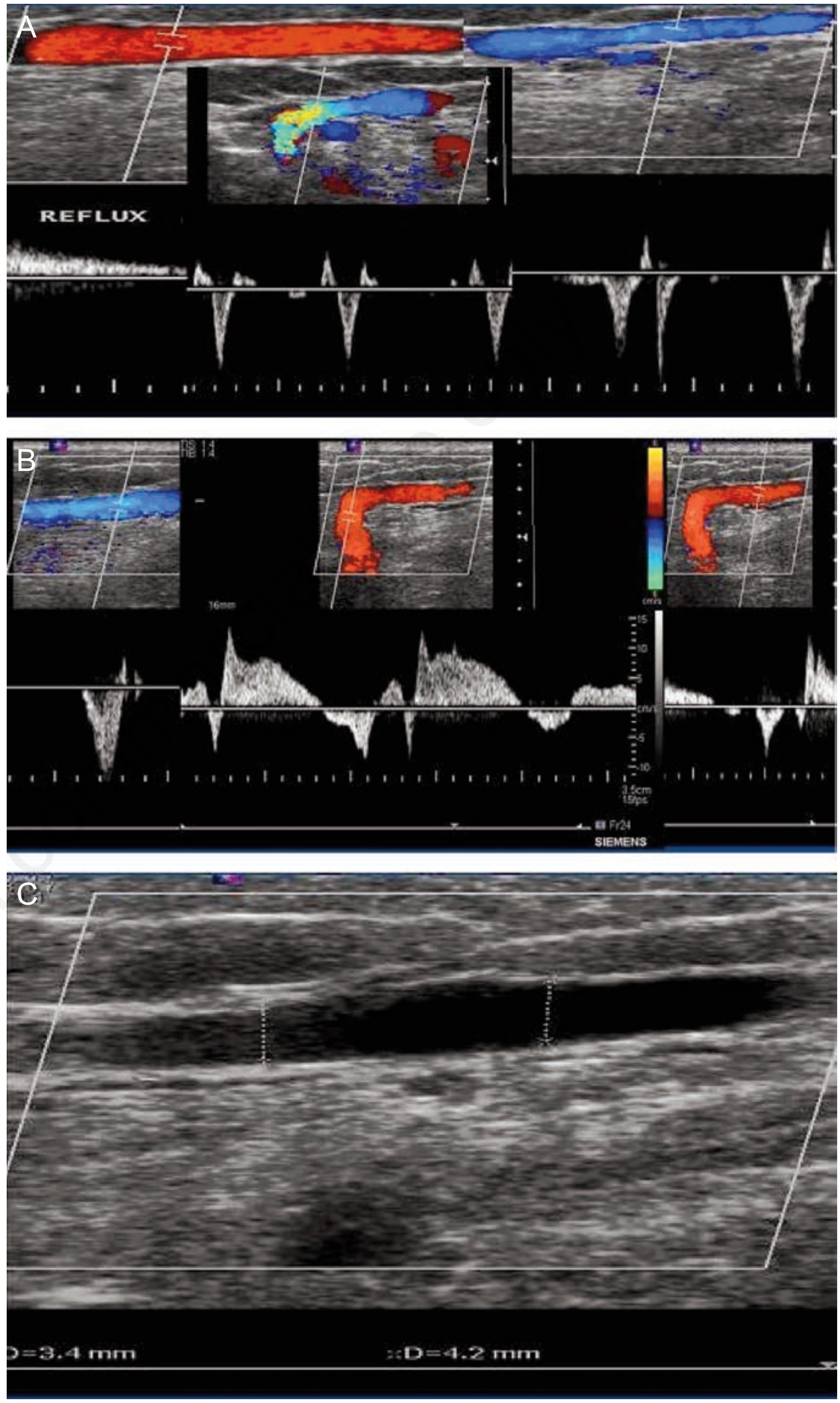

Figure 2. Ultrasonographic details. A) Paratibial perforating vein (PTPV) as drainage of great saphenous vein (GSV) reflux. B) PTPV as source of GSV distal reflux. C) Change in diameter showing GSV enlargement distally, suggesting distal reflux.

(P<0.001) based on general prevalence of GSV patterns of reflux and general prevalence of PTPV subgroups. The altered proportions with pathophysiological significance, having higher prevalence than expected, were:

- PTPV drainage of GSV reflux (n=281) and GSV segmental reflux, 168 *vs* 144 or 60% *vs* 51% (P<0.05); therefore, PTPV as a GSV reflux drainage had a higher association with GSV segmental reflux;
- PTPV source of GSV reflux (n=73) and GSV distal reflux, 16 *vs* 6 or 22% *vs* 8% (P<0.05); therefore PTPV was a significant source of GSV distal reflux;
- Refluxing PTPV without relation to GSV flow (n=49) and GSV diffuse reflux, 8 *vs* 2 or 16% *vs* 4% (P<0.05); if PTPV reflux was not associated with GSV reflux, the GSV reflux pattern bypassed the PTPV and was diffuse;
- Enlarged PTPV without reflux (n=39) and i) GVS diffuse reflux, 7 *vs* 1 or 18% *vs* 3% (P<0.05); and ii) GSV without reflux, 8 *vs* 1 or 21% *vs* 3% (P<0.05).

Therefore, there was a lack of association between abnormal PTPV despite normal flow and GSV patterns of reflux, being either absent or diffuse.

In summary, PTPV was mostly normal in early stages of CVVI in women, PTPV drained GSV reflux, most commonly GSV segmental reflux; as a source of reflux, PTPV was mostly associated to GSV distal reflux to the ankle; and PTPV, either enlarged but not refluxing, or, associated with non-saphenous reflux, showed no relation to GSV patterns of reflux.

Discussion

This investigation focused on a very specific population: women with CVVI at early stages. The sampled population had a high prevalence of GSV segmental pattern of reflux, and a relatively low prevalence of SFJ reflux. In particular, a 19% prevalence of SFJ was slightly higher than that of 12% described for women with varicose veins.[7] It is our impression that perforating veins become abnormal as CVVI progresses, not necessarily at the very early stages. About 4/5 of the extremities examined at this ultrasound laboratory have GSV reflux, but only about 1/5 of the lower extremities evaluated qualified for a study of a proximal, medial calf, PTPV.

The PTPV was selected for this specific study based on the perception of specialists accustomed to map superficial veins in patients with CVVI. In addition, paratibial perforating veins are commonly palpated during clinical examinations. Quantitative knowledge of common prevalence and an extended, detailed descriptions of less frequent findings were desirable. An specific objective often clarifies doubts more so than extensive data collections of mixed clinical conditions. Therefore, our studies are being restricted to women with telangiectasias, varicose veins, and mild swelling, and, in this particular instance, to women with abnormalities of a specific perforating vein. Other subgroups demand additional research: men, athletes and patients with special conditions such as recurrence, malformations, past thrombosis, *etc*.

The PTPV diameters described herein provided additional information when compared to diameters previously mentioned in the literature.[14] Normal diameters of perforators at the medial aspect of the leg averaged 2.2 mm while this study indicated that PTPV draining GSV reflux in women averaged 2.6 mm. Draining perforating veins, therefore, may be dilated. Also, this study indicated that refluxing PTPV in women averaged 2.9 mm while severely abnormal medial perforators had an average diameter of 3.7 mm.[14] Possible differentials include: i) refluxing perforators at the distal leg may be larger than refluxing PTPV; ii) reflux was not accessed in PTPV draining GSV reflux; iii) this study included only women; and iv) this population represents subjects with early stage of disease.

The most common finding in this study was an uneventful PTPV; previous publications have emphasized the major role of tributaries over perforating veins in early stages of disease.[1,11] Otherwise, the most commonly abnormal PTPV drained segmental GSV reflux. The next most common finding, also within pathophysiological expectations, was a refluxing PTPV as a source of GSV distal reflux. PTPV abnormalities were not strongly related to GSV diffuse reflux or GSV without reflux. These findings are consistent with early CVVI stages.

In summary, contributions of paratibial perforating vein abnormalities to early stages of chronic venous valvular insufficiency were evaluated in women. Only about 1 in 5 of more than two thousand extremities evaluated had PTPV abnormalities. The most common, active role of the PTPV was to drain reflux restricted to a segment of the GSV. Secondarily, this perforating vein caused reflux at the distal portion of the GSV. Exceptionally, PTPV had reflux not associated with the GSV. Perforating veins may not be frequently exposed to hydrostatic columns of pressure, but a large PTPV diameter may indicate risk of CVVI progression even in the absence of reflux. Specific research may indicate that abnormal perforating veins caus-

Table 1. Pathophysiology of proximal, medial leg, paratibial perforating veins in women with early chronic venous valvular insufficiency: prevalence of flow or size abnormalities on ultrasound examinations.

Condition	Right leg (n)	Left leg (n)	Total (n)	P* R *vs* L
GSV reflux drainage	138 (64%)	143 (63%)	281 (64%)	0.70
GSV reflux source	31 (14%)	42 (18%)	73 (17%)	0.27
Refluxing perforator°	24 (11%)	25 (11%)	49 (11%)	0.93
Non-refluxing perforator#	21 (10%)	18 (8%)	39 (9%)	0.48
Total	214 (100%)	228 (100%)	442 (100%)	0.35
PTPV significant reflux	55 (26%)	67 (29%)	122 (28%)	0.39

GSV, great saphenous vein; R, right; L, left; PTPV, paratibial perforating veins. *Probability by Chi-square proportions between right and left leg prevalence for each condition in relation to the total for each leg; °not major source of GSV reflux; #not major drainage of GSV reflux but considered to have large diameter ≥3 mm and/or unusual anatomy such as length and tortuosity.

Table 2. Proximal, medial leg, paratibial perforating veins in women with early-stage chronic venous valvular insufficiency: relationship between ultrasound measured diameters - or fascial aperture representing maximum potential diameter - and flow patterns.

Diameter	All	GSV reflux drainage	GSV reflux source	Refluxing perforator*	Non-refluxing perforator°
<2.0 mm	9 (2%)	9 (100%)	0	0	0
2.0 - <2.5 mm	127 (29%)	96 (76%)	19 (15%)	9 (7%)	3 (2%)
2.5 - <3.0 mm	147 (33%)	99 (67%)	25 (17%)	21 (14%)	2 (1%)
3.0 - <3.5 mm	117 (26%)	56 (48%)	19 (16%)	10 (9%)	32 (27%)
3.5 - <4.0 mm	30 (7%)	18 (60%)	7 (23%)	4 (13%)	1 (3%)
≥4.0 mm	12 (3%)	3 (25%)	3 (25%)	5 (42%)	1 (8%)
Total	442 (100%)	281	73	49	39

GSV, great saphenous vein. *Source of non-GSV reflux; °not major drainage of GSV reflux.

Table 3. Proximal, medial leg, paratibial perforating veins (PTPV) in women with early-stage chronic venous valvular insufficiency: associations of PTPV flow and great saphenous vein reflux patterns.

GSV reflux	All	GSV reflux drainage	GSV reflux source	Refluxing perforator*	Non-refluxing perforator°
Segmental	227 (51%)	168 (60%)	33 (45%)	16 (33%)	10 (26%)
Multisegmental	89 (20%)	60 (21%)	17 (23%)	10 (20%)	2 (5%)
Multiseg+SFJ	41 (9%)	27 (10%)	7 (10%)	4 (8%)	3 (8%)
Distal	34 (8%)	0	16 (22%)	10 (20%)	8 (21%)
Proximal	28 (6%)	26 (9%)	0	1 (2%)	1 (3%)
Diffuse	15 (3%)	0	0	8 (16%)	7 (18%)
Sem refluxo	8 (2%)	0	0	0	8 (21%)
Total	442(100%)	281(100%)	73 (100%)	49(100%)	39(100%)
Segmental	227 (100%)	168 (74%)	33 (15%)	16 (7%)	10 (4%)
Multisegmental	89 (100%)	60 (67%)	17 (19%)	10 (11%)	2 (2%)
Multiseg+SFJ	41 (100%)	27 (66%)	7 (17%)	4 (10%)	3 (7%)
Distal	34 (100%)	0	16 (47%)	10 (29%)	8 (24%)
Proximal	28 (100%)	26 (93%)	0	1 (4%)	1 (4%)
Diffuse	15 (100%)	0	0	8 (53%)	7 (47%)
Sem refluxo	8 (100%)	0	0	0	8 (100%)
Expected statistical prevalence					
	Probability	0.6357	0.1652	0.1109	0.0882
Segmental	0.5136	144	37	25	20
Multisegmental	0.2014	57	15	10	8
Multiseg+SFJ	0.0928	26	7	5	4
Distal	0.0769	22	6	4	3
Proximal	0.0633	18	5	3	2
Diffuse	0.0339	10	2	2	1
	0.0181	5	1	1	1

GSV, great saphenous vein; SFJ, saphenofemoral junction. *Not major source of GSV reflux; °not major drainage of GSV reflux.

ing reflux may already represent a more advanced stage of disease than usual, primary venous valvular insufficiency.

Conclusions

Detailed evaluation of a major perforating vein in the calves of women with early stages of CVVI confirmed a primary re-entry role draining GSV reflux. PTPV was linked to reflux in about 1 of 5 legs with CVVI. PTPV was an uncommon major source of reflux in about 1 of 20 lower extremities. Detailed US of PTPV, however, insured over 80% accuracy in CVVI mapping.

References

1. Engelhorn C, Engelhorn A, Casagrande C, Salles-Cunha SX. Sources and drainages of saphenous vein reflux in patients with primary varicose veins. Poster, final program of the American Venous Forum 11th Annual Meeting of the, Dana Point, CA, February 18-21, 1999, p 96.
2. Allegra C, Antignani PL, Bergan JJ, et al. International Union of Phlebology Working Group. The "C" of CEAP: suggested definitions and refinements: an International Union of Phlebology conference of experts. J Vasc Surg 2003;37:129-31.
3. Eklöf B, Rutherford RB, Bergan JJ, et al. American Venous Forum International Ad Hoc Committee for Revision of the CEAP Classification. Revision of the CEAP classification for chronic venous disorders: consensus statement. J Vasc Surg 2004;40:1248-52.
4. Coleridge-Smith P, Labropoulos N, Partsch H, et al. Duplex ultrasound investigation of the veins in chronic venous disease of the lower limbs - UIP consensus document. Part I. Basic principles. Eur J Vasc Endovasc Surg 2006;31:83-92.
5. Cavezzi A, Labropoulos N, Partsch H, et al. Duplex ultrasound investigation of the veins in chronic venous disease of the lower limbs - UIP consensus document. Part II. Anatomy. Eur J Vasc Endovasc Surg 2006;31:288-99.
6. Engelhorn CA, Engelhorn AL, Cassou MF, Salles-Cunha S. Patterns of saphenous venous reflux in women presenting with lower extremity telangiectasias. Dermatol Surg 2007;33:282-8.
7. Engelhorn CA, Engelhorn AL, Cassou MF, Salles-Cunha SX. Patterns of saphenous reflux in women with primary varicose veins. J Vasc Surg 2005;41:645-51.
8. Engelhorn CA, Manetti R, Baviera MM, et al. Progression of reflux patterns in saphenous veins of women with chronic venous valvular insufficiency. Phlebology 2012;27:25-32.
9. Caggiati A, Bergan JJ, Gloviczki P, et al. Nomenclature of the veins of the lower limb: Extensions, refinements, and clinical application; International Interdisciplinary Consensus Committee on Venous Anatomical Terminology. J Vasc Surg 2005;41:719-24.
10. Engelhorn C, Engelhorn A, Salles-Cunha S, et al. Relationship between reflux and greater saphenous vein diameter. J Vasc Technol 1997;21:167-72.
11. Engelhorn CA, Engelhorn AL, Cassou MF, et al. Anatomofunctional classification of saphenous insufficiency by color-flow duplex-Doppler ultrasound directed to planning of varicose vein surgery. J Vasc Bras 2004;3:13-9.
12. Engelhorn CA, Cassou MF, Engelhorn AL, Salles-Cunha SX. Does the number of pregnancies affect patterns of great saphenous vein reflux in women with varicose veins? Phlebology 2010;25:190-5.
13. Labropoulos N, Tiongson J, Pryor L, et al. Definition of venous reflux in lower extremity veins. J Vasc Surg 2003;38:793-8.
14. Sandri JL, Barros FS, Pontes S, et al. Diameter-reflux relationship in perforating veins of patients with varicose veins. J Vasc Surg 1999;30:867-7.

