

Correlation of Perforating Vein Incompetence with Extent of Great Saphenous Insufficiency: Cross Sectional Study

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Aim	To explore the correlation between perforating vein incompetence and the extent of great saphenous vein insufficiency according to Hach.
Methods	Duplex ultrasound was used to determine the number of incompetent perforators and diameter of perforating veins, and the level of great saphenous vein reflux and the presence or absence of deep reflux in 118 lower limbs (59 patients). There were 19 limbs with no clinical evidence of venous disease (CEAP – clinical, etiological, anatomical, pathological grade 0), 16 limbs with telangiectasias only (CEAP grade 1), 36 limbs with varicose veins (CEAP 2), 26 limbs with edema (CEAP 3), and 21 limb affected with lipodermatosclerosis but not ulcer (CEAP 4).
Results	Both the number of incompetent perforators and the average diameter of duplex detectable perforators per limb correlated significantly with the extent of great saphenous vein insufficiency (Pearson correlation coefficients were 0.55 and 0.44, respectively; $P < 0.001$ for both). The number of incompetent perforators and the average diameter of perforators per limb were significantly higher with the deteriorating CEAP grade (Kruskal-Wallis H test; $P < 0.001$). The mean number of incompetent perforators per limb did not differ significantly in the absence or presence of deep reflux (0.8 ± 1.26 vs 1.3 ± 1.6 , t test, $P = 0.172$), the average diameter of perforators per limb was higher in the presence of deep reflux (2.4 ± 2 mm vs 3.7 ± 1.1 mm, t test, $P = 0.023$).
Conclusion	The extent of great saphenous vein insufficiency correlated with an increase in the number and the diameter of perforators. The perforators' association with deep venous reflux was much poorer. Clinical presentation worsened with the deteriorating duplex signs of perforators' incompetence.

Perforating veins take blood from the superficial venous system, pass through the muscle fascia, and deliver it to the deep venous system of the lower extremities (1). They contain valves, which block reverse blood flow (1-3). However, if the valves are damaged, blood remains in superficial veins due to the higher pressure in the deep system, producing further deterioration of their function (2,3). The venous perforators are usually insufficient if they are larger than 3.9 mm in diameter (4,5). Despite the great number of studies on the role of venous perforators in pathogenesis of chronic venous insufficiency, their hemodynamic role is still controversial (2-10). Delis et al (8,9), as

well as Sandri et al (10) found that the prevalence of incompetent perforators increases linearly with the clinical severity of chronic venous insufficiency (stratified according to clinical, etiological, anatomical, and pathological classification; ref. 11) and it increases significantly with the prevalence of deep venous incompetence. Labropoulos et al (4,12-14), on the other hand, found that perforators' incompetence was most frequently associated with reflux in superficial veins (74%), followed by reflux in both superficial and deep (34.21%) and deep alone (9.5%), ie, deep venous reflux is rarely the primary cause. Nevertheless, it is undisputed that the clinical presentation deteriorates

rates with the number of incompetent perforators and with the average diameter of perforating veins per limb (2-5). The association between the presence of insufficiency of great saphenous vein and perforating veins has been established (5,16-18). The purpose of this study was to determine whether the extent of great saphenous vein insufficiency according to the system proposed by Hach (19) correlated with the number of incompetent perforators, and the average diameter of the perforators.

Patients and Methods

Eligibility Criteria

Fifty-nine consecutive patients (118 limbs) were prospectively included in the study. They were referred for duplex scanning by the primary care physician or a specialist with suspicion of venous disease. Exclusion criteria were: 1) venous ulceration, as we found the prevalence of that clinical feature too low to be representative; there were only two, ie 1.6% limbs with venous ulcers, which revealed great disproportion to the size of other clinical groups which counted 16-36 limbs, ie 13.6%-30.5% of total number of limbs; 2) acute deep venous thrombosis; and 3) non venous pathology, such as Baker's cyst, and muscle rupture.

Patients

The limbs were divided into clinical groups according to clinical, etiological, anatomical, and pathological classification (CEAP; ref. 11). The clinical groups were 19 limbs that had no clinical evidence of venous disease (CEAP 0), 16 limbs that had telangiectasias (CEAP 1), 36 limbs that had varicose veins (CEAP 2), 26 limbs that had edema (CEAP 3), and 21 limb that had skin changes, ie, lipodermatosclerosis, with no history of ulceration (CEAP 4).

There was a significant difference in female/male ratio, as well as in affected legs' num-

ber across different CEAP grades (Table 1). The increase in age across the clinical groups reached statistical significance at the level $P=0.024$ (one-way analysis of variance, Table 1).

Methods of Examination

Color flow duplex ultrasound scanning (Siemens Sonoline G50 Ultrasound Imaging System, Siemens Medical Solutions USA, Inc. 2002, 7.5 MHz transducer) was performed to determine the number and the diameter of medial calf perforating veins and the presence of deep and superficial main stem venous reflux. The deep and superficial (saphenous) venous systems were examined with the patient almost upright, supported on tilting examination table. Blood flow was induced by means of calf squeeze-and-release maneuver. Pathological reflux was defined as reflux exceeding 0.5 seconds duration (20,21).

Medial calf perforating veins were defined as vessels situated between the medial subcutaneous border of the tibia and the posterior midline of the calf, which were seen to cross the deep fascia and connect the deep venous system, usually posterior tibial vein, with the superficial venous system (5). Medial calf perforators were sought with the subject seated on a couch with the legs dependent, hanging freely (5,8).

Each perforator was examined by the use of color-flow Doppler (7.5 MHz transducer Siemens Sonoline G50 Ultrasound Imaging System, Siemens Medical Solutions USA, Inc. 2002F). No standard technique for the examination of perforating veins exists in the literature. The maximum subfascial diameter of the vessel was recorded (5). A vessel was determined to be competent when it exhibited only inward flow and to be incompetent when it was seen to allow deep to superficial venous flow, no matter whether the flow was unidirectional (outward) or bidirectional (5).

The extent of greater saphenous vein insufficiency was based on the classification system

Table 1. Demographic features of 59 patients (118 lower limbs) stratified across clinical, etiological, anatomical, pathological (CEAP)* grades

Parameters	CEAP grade					P
	0	1	2	3	4	
Female/male	10/9	15/1	35/1	21/5	14/7	<0.001†
Limbs (No.)	19	16	36	26	21	0.034†
Age (years, mean±standard deviation)	51±15	55±15	56±13	61±10	63±8	0.024‡

*Clinical, etiological, anatomical, pathological grades (11): 0 - no clinical changes; 1 - telangiectasias only; 2 - varicose veins; 3 - venous edema; 4 - skin changes (lipodermatosclerosis).

† χ^2 test.

‡One-way analysis of variance.

Table 2. Parameters of venous insufficiency according to clinical, etiological, anatomical pathological (CEAP) grade

Insufficiency parameters	CEAP* grade					P
	0	1	2	3	4	
Deep venous insufficiency (%)	0	2 (12.50)	3 (8.3)	4 (15.4)	3 (14.3)	<0.001†
Great saphenous vein's insufficiency level (median, interquartile range)	0 (0-0)	0 (0-0.375)	0 (0-1)	2 (0-3)	2 (1.25-4)	<0.001‡
Number of all perforators per limb (median, interquartile range)	0 (0-1)	1 (0-1.75)	1 (0-2)	2 (1-3)	3 (2.5-5)	<0.001‡
Number of incompetent perforators per limb (median, interquartile range)	0 (0-0)	0 (0-0)	0 (0-1)	1 (0-2)	2 (1-4)	<0.001‡
Average diameter of perforators per limb (in mm, median, interquartile range)	0 (0-1.5)	1.5 (0-2.9)	2.4 (0-3.3)	3.7 (2.9-5.1)	3.8 (3.3-5.0)	<0.001‡

*Clinical, etiological, anatomical, pathological grade (11): 0 - no clinical changes, 1 - telangiectasias only, 2 - varicose veins, 3 - venous edema, 4 - skin changes, ie, lipodermatosclerosis.

† χ^2 test, ($P=0.517$ for CEAP 1-4 solely).

‡Kruskal-Wallis test.

proposed by Hach (19). The score ranged from 0 to 4 according the appearance of duplex detectable reflux in great saphenous vein in presence of Valsalva maneuver: score 0 – there was no reflux, score 1 – reflux from the saphenofemoral junction down to middle thigh, 2 – reflux down to knee, 3 – reflux down to middle calf, 4 – reflux down to ankle.

Statistical Analysis

Statistical analysis was performed by means of the Statistical Package for Social Sciences, version 11.5 (SPSS Inc, Chicago, IL, USA). Parametric statistics was used in cases where the sample size was large enough. In cases where the sample size was small, samples were tested for normality of distribution (one-sample Kolmogorov-Smirnov test). When samples showed normal distribution, parametric statistics was applied and nonparametric when the distribution was not normal. When the distribution among samples was mixed, we decided to use nonparametric statistics, due to the small size of the samples (Table 2). One-way analysis of variance was used to examine whether the means of the outcome variables were significantly different across CEAP grades. *Post hoc* test for a small number of pairs was also applied (Bonferroni test). *T* test was used to determine whether different means of the outcome variables differed significantly across two categories. Where needed, Kruskal-Wallis H test was applied, as the nonparametric analog of one-way analysis of variance. Mann-Whitney *U* test, which is equivalent to the Kruskal-Wallis test for two groups, was used to perform multiple comparisons between different pairs. Chi-square test was used to examine whether different frequencies differed significantly across CEAP grades. Pearson correlation was used to examine the correlation between the extent of great saphenous vein insufficiency and the number of incompetent perforators, and the

average diameter of perforators per limb. In all tests, α value of 0.05 was taken.

Results

In CEAP groups 2 and 3, ie the moderate level of the disease, the prevalence of patients was the highest. Nineteen of the examined extremities did not have any clinical signs of venous disease (Table 1).

The women/men ratio for all CEAP grades was far higher in women's favor, particularly in groups 1 and 2, ie women developed telangiectasias and varicose extrafascial veins more often (Table 1). An increase in the mean patients' age with the increase in CEAP grade was also observed (Table 1). However, Bonferroni *post hoc* test showed that only CEAP groups 0 and 4 differed significantly in mean age ($P=0.046$), whereas other CEAP groups did not.

The analysis of the level of reflux in the great saphenous vein (Fig. 1) demonstrated that the majority of limbs tested ($n=70$; 59.3%) did not exhibit signs of the insufficiency, whereas in the 48 (40.7%) limbs with reflux there were 15 (12.7%) with the level 4, 12 (10.2%) with the level 3, 9 (7.6%) with the level 2, and 7 (5.9%) with the level 1 reflux. Deterioration of CEAP grade was followed by an increased number of legs with the insufficient great saphenous vein, and a decreased number of legs without great saphenous vein insufficiency as shown in Figure 2. The highest extent of the great saphenous vein's insufficiency was present in all CEAP categories, even in the extremities without any clinical symptoms; on the other hand, we found the lack of great saphenous vein's reflux even in the extremities with the highest clinical level of the disease.

The prevalence of deep venous reflux was significantly higher for positive than for negative CEAP grades, whereas there was no significant

difference among the different positive CEAP grades (ie, CEAP 1-4, Table 2).

The extent of great saphenous vein insufficiency increased significantly with deteriorat-

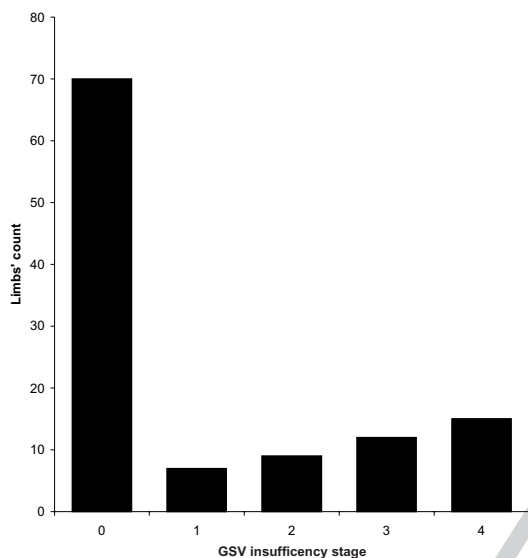


Figure 1. Distribution of great saphenous vein insufficiency stages after Hach (19) in 118 legs. Score 0 – there was no reflux, score 1 – reflux from the saphenofemoral junction down to middle thigh, 2 – reflux down to knee, 3 – reflux down to middle calf, 4 – reflux down to ankle. GSV – greater saphenous vein.

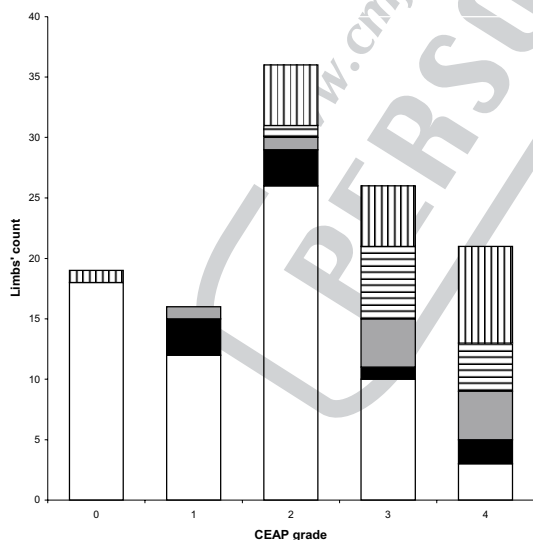


Figure 2. Greater saphenous vein insufficiency stages (after Hach, ref. 19) across different clinical, etiological, anatomical, pathological (CEAP) grades in 118 limbs. Great saphenous vein insufficiency stages: open bars – level 0; closed bars – level 1; grey bars – level 2; horizontal lines – level 3; vertical lines – level 4.

ing CEAP grade, as well as the total number of perforating veins per limb, number of incompetent perforators per limb, and average perforators' diameter per limb (Table 2). However multiple comparison, which was performed *post hoc* using Mann-Whitney *U* test, showed that the significant difference in the extent of great saphenous vein insufficiency was observed only between CEAP groups 0 and 3 ($P < 0.001$), 0 and 4 ($P < 0.001$), 1 and 3 ($P = 0.003$), 1 and 4 ($P < 0.001$), 2 and 3 ($P = 0.01$), and 2 and 4 ($P < 0.001$). In the same way, the total number of perforating veins per limb showed significant difference only between CEAP groups 0 and 2 ($P = 0.018$), 0 and 3 ($P < 0.001$), 0 and 4 ($P < 0.001$), 1 and 4 ($P < 0.001$), 2 and 4 ($P < 0.001$), and 3 and 4 ($P < 0.001$). The number of incompetent perforators per limb showed significant difference between CEAP groups 0 and 3 ($P < 0.001$), 0 and 4 ($P < 0.001$), 1 and 3 ($P < 0.001$), 1 and 4 ($P < 0.001$), 2 and 3 ($P < 0.001$), 2 and 4 ($P < 0.001$), and 3 and 4 ($P = 0.001$). The average diameter of perforators per limb showed significant difference between CEAP groups 0 and 2 ($P = 0.006$), 0 and 3 ($P < 0.001$), 0 and 4 ($P < 0.001$), 1 and 3 ($P < 0.001$), 1 and 4 ($P < 0.001$), 2 and 3 ($P < 0.001$), and 2 and 4 ($P < 0.001$). In all cases, the higher CEAP grade had the higher median great saphenous insufficiency level, higher total number of perforators per limb, higher number of incompetent perforators and higher perforators diameter per limb (Table 2).

The presence of deep reflux was not associated with an increased mean number of incompetent perforators per limb, but with signifi-

Table 3. Average number of incompetent perforators and average diameter of perforators per limb in presence or absence of deep venous reflux or great saphenous vein's reflux in lower limbs

Vein†	Insufficiency*		P
	positive	negative	
Deep:			
No. of limbs	12	106	<0.001†
No. of incompetent perforators per limb	1.3±1.6	0.8±1.26	0.172§
average diameter of perforators per limb (mm)	3.7±1.1	2.4±2	0.023§
Great saphenous:			
No. of limbs	49	69	0.066†
No. of incompetent perforators per limb	1.6±1.6	0.3±0.65	<0.001§
average diameter of perforators per limb (mm)	3.5±1.4	1.8±2	<0.001§

*Deep insufficiency: positive – presence of duplex detectable deep reflux; negative – absence of duplex detectable deep reflux. Great saphenous vein's insufficiency: positive – presence of duplex detectable reflux, negative – absence of duplex detectable reflux.

†Data are expressed as mean±standard deviation.

‡ χ^2 -test.

§Student t-test.

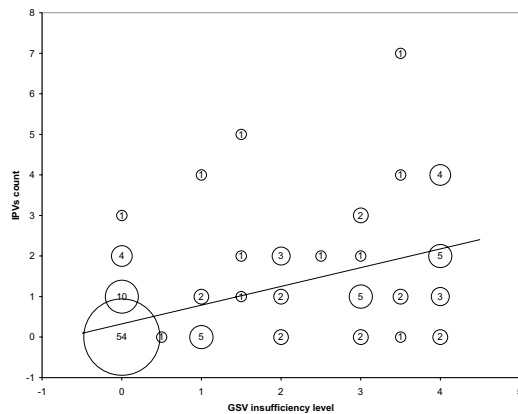


Figure 3. Correlation between the greater saphenous vein insufficiency stage (after Hach, ref. 19) and the number of incompetent perforators per limb. GSV – great saphenous vein; IPVs – incompetent perforating veins. Bubbles' size is proportional to the number of cases, which is written in the center of each bubble. Pearson correlation coefficient $r=0.55$, $P<0.001$.

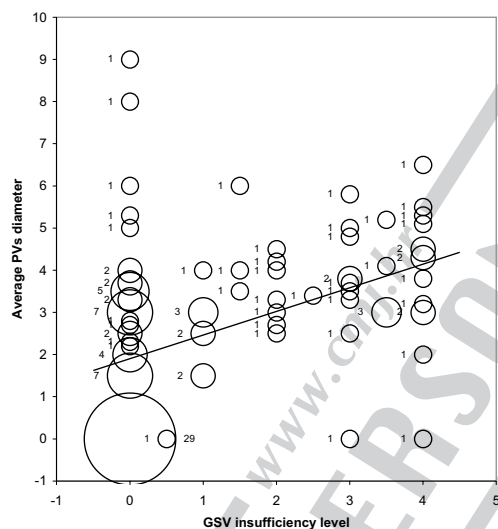


Figure 4. Correlation between the greater saphenous vein insufficiency stage (after Hach, ref. 19) and the average diameter of perforating veins per limb. GSV – great saphenous vein; PVs – perforating veins. Bubbles' size is proportional to the number of cases, which is written next to each bubble. Pearson correlation coefficient: $r=0.44$, $P<0.001$.

cantly increased average diameter of perforators per limb (Table 3). The presence of great saphenous vein insufficiency was associated both with an increased mean number of incompetent perforators per limb and increased average perforating veins' diameter per limb (Table 3).

Statistically significant correlation was found between the extent of the great saphenous

vein insufficiency and the number of incompetent perforators per limb ($r=0.55$; $P<0.001$, Figure 3). There was also statistically significant correlation between the extent of great saphenous vein insufficiency and the average diameter of the limb perforators ($r=0.44$; $P<0.001$, Figure 4).

Discussion

The principal finding of the present study was that deteriorating great saphenous vein insufficiency correlated both with an increase in the prevalence of incompetent perforators per limb and an increase in the mean diameter of the duplex-detectable calf perforators. To the best of our knowledge, a study with similar results has not been published in literature.

The fact that the mean number of incompetent perforators was significantly higher with the presence of great saphenous vein reflux, but not with the presence of deep reflux, suggests that the perforators' incompetence represents a significant factor in great saphenous vein insufficiency, which could be more important than the deep venous insufficiency.

Stuart et al (5) published a study performed on 311 legs to establish the perforators' role in pathogenesis of skin changes. They also observed the increase in age with the deterioration of CEAP grade. However the women/men ratio did not change across different CEAP grades. They also observed the increased prevalence of deep reflux with the deterioration of CEAP, but there was no difference in the prevalence of greater saphenous vein insufficiency. They observed an increase in the number of incompetent perforators and an increased perforators' diameter with the deteriorating CEAP grade, similar to our results. They did not directly observe the relationship between great saphenous vein insufficiency and perforators' insufficiency. They claimed that the most of incompetent perforators were associated with the superficial and/or deep reflux, whereas our results attributed the mean role to the greater saphenous vein reflux and give less significance to the deep system.

Labropoulos et al (4) also found that an increase in the number of incompetent perforators and an increase in the diameter of perforating veins correlated with a deteriorating CEAP grade. Perforating vein incompetence was more often associated with the superficial system than the deep

system. These results correlate with our data. These authors also reported that an increase in the perforators' diameter was associated with an increase in the percentage of incompetent perforators and that the diameter of 3.9 mm or greater was sufficient for predicting the perforators' incompetence (the accuracy was 91%).

Rutherford et al (18) also found the association between varicose veins and perforators' incompetence, which is consistent with our findings. They, however, studied the prevalence of incompetent perforating veins in the presence of recurrent varicose veins and found that it was higher. But, like Stuart et al (5), these authors only registered the presence or absence of superficial reflux, and did not classify the severity of the great saphenous vein insufficiency (19).

In a study performed on 90 legs belonging to 67 patients, Delis et al (8) dealt with the hemodynamics of incompetent perforators in different CEAP grades. They found that the prevalence of incompetent perforators linearly increased with the severity of chronic venous insufficiency, but they, unlike us, emphasized the role of the deep system, giving lower priority to the superficial system.

In a study performed on 304 legs, Yamamoto et al (6) observed the venous perforators' diameter-reflux relationship and tried to determine the accuracy of duplex scanning in diagnosing venous disease. They claimed that the diameter of incompetent perforators was greater than the diameter of competent ones. With the increased diameter, the percentage of incompetent perforating veins was higher, and the percentage of competent perforators lower, which justified the usage of mean diameter of perforating veins per limb as a parameter of perforators' incompetence in our study.

In their cohort study performed on 112 legs, Navarro et al (22) found that the diameter of great saphenous vein correlated with the CEAP grade. This was similar to our results in Table 2. However, we did not measure the diameter of great saphenous vein but determined its insufficiency level according to the Hach classification (19).

The crucial question facing surgeons performing saphenous vein surgery is whether hemodynamic or clinical benefits can be achieved with additional perforator vein resection, in pa-

tients with chronic venous insufficiency (5). Our data strongly suggest that, similar to Stuart's findings (5), with the deterioration of CEAP grade, there is an increased capacity for blood volumes to be expelled down a pressure gradient through both dilated low-resistance incompetent perforators and the incompetent greater saphenous vein during calf systole. Based on our results, only saphenous diagnostics and surgery would probably be insufficient, and the perforators should also be included in the procedure. Iafrati et al (23), in the conclusion of their study performed on 51 limbs which underwent subfascial endoscopic perforator surgery, suggested an "aggressive approach to superficial and perforating veins' reflux." Nevertheless, our pre-treatment, cross-sectional study, due to its character, could not give definitive evidence for the surgical treatment of perforating veins.

The limitations of the study are its cross-sectional character, and relatively small number of included entities. In conclusion, our results on correlation between the great saphenous vein insufficiency extent and both the number of incompetent perforating veins and the mean diameter of perforators per limb point out that the superficial system, ie, great saphenous vein and the extent of the incompetence level is strongly associated with the perforating veins insufficiency. The association of perforating veins with the deep system, according to our results, is much weaker, which is consistent with prior published data (4). Further prospective longitudinal investigations of the deep and the superficial systems' competence, as well as perforators are needed to establish the definite causal relationship among them.

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