Duplex assessment of venous reflux and chronic venous insufficiency: The significance of deep venous reflux

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Purpose: This study was undertaken to examine the role of superficial and deep venous reflux, as defined by duplex-derived valve closure times (VCTs), in the pathogenesis of chronic venous insufficiency.
Methods: Between January 1992 and November 1995, 320 patients and 500 legs were evaluated with clinical examinations and duplex scans for potential venous reflux. VCTs were obtained with the cuff deflation technique with the patient in the upright position. Imaging was performed at the saphenofemoral junction, the middle segment of the greater saphenous vein, the lesser saphenous vein, the superficial femoral vein, the profunda femoris vein, and the popliteal vein. Not all patients had all segments examined because tests early in the series did not examine the profunda femoris or lesser saphenous vein and because some patients had previous ligation and stripping or venous thrombosis. VCTs were examined for individual segment reflux, grouped into superficial and deep systems, and then correlated with the clinical stage as defined by the SVS/ISCVS original reporting standards in venous disease. Segment reflux was considered present if the VCT was greater than 0.5 seconds, and system reflux was considered present if the sum of the segments was greater than 1.5 seconds. Between-group differences were analyzed with analysis of variance and post hoc tests where appropriate.
Results: Sixty-nine limbs studied were in class 0, 149 limbs were in class 1, 168 limbs were in class 2, and 114 limbs were in class 3. VCTs in the superficial veins were significantly lower in class 0 than in the other clinical classes. There was no difference in superficial reflux in the symptomatic limbs (classes 1 to 3). Reflux VCTs in the superficial femoral and popliteal veins increased as the clinical symptoms progressed, with a significant increase in class 3 ulcerated limbs when compared with nonulcerated limbs. The incidence of deep venous reflux was 60% in class 3 limbs, compared with 29% in class 2 limbs, whereas the incidence of superficial venous reflux did not differ among the symptomatic limbs. Isolated superficial femoral and popliteal vein reflux was uncommon, even in class 3 limbs, but combined superficial femoral and popliteal vein reflux was found in 53% of class 3 limbs, compared with 18.5% of class 2 limbs.
Conclusions: Reflux in the deep venous system plays a significant role in the progression of chronic venous insufficiency. Deep system reflux increases as clinical changes become more severe, with significant axial reflux contributing to ulcer formation. (J Vasc Surg 1996;24:755-62.)

Venous reflux occurs as a result of either post-thrombotic valve destruction, primary valvular incompetence, or vein dilation. It may be present in the superficial venous system, in the deep venous system, or in both systems. Identification of this reflux is important in the treatment algorithms of patients who have venous disease, and a variety of noninvasive tests are available to assess patients who have reflux. Duplex ultrasonography has become the test of choice[1] because of its ability to define anatomically the site of reflux (or obstruction) and to quantify the amount of reflux.[2-4] We have used duplex-derived quantitative valve closure times (VCT) extensively as a means to screen patients for venous insufficiency, as well as to identify patients

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who may be treated with ligation and stripping of superficial veins or those who may need to undergo phlebographic evaluation as a prelude to possible deep venous reconstruction. Many studies have used duplex scans to assess venous reflux, but few have attempted to quantify reflux. This study, using quantitative duplex VCTs, was undertaken to determine the influence of reflux in the superficial and deep venous systems in the progression of chronic venous insufficiency (CVI).

METHODS

Between January 1, 1992, and November 30, 1995, 545 limbs in 348 patients underwent duplex evaluation of VCT. Forty-five limbs in 28 patients that had incomplete data were excluded from study. This study is composed of the remaining 320 patients and 500 limbs.

Patients were examined in the vascular surgery clinic by a staff vascular surgeon, and each limb was assigned a clinical grade according to the original Society for Vascular Surgery/International Society for Cardiovascular Surgery, North America, reporting standards in venous disease[5]: class 0, asymptomatic; class 1, mild CVI with signs and symptoms of mild to moderate ankle swelling, mild discomfort, and localized or generalized dilatation of the superficial veins; class 2, moderate CVI, including hyperpigmentation of the skin, moderate brawny edema, and subcutaneous fibrosis without ulceration; class 3, severe CVI, chronic distal leg pain associated with ulcerated or preulcerative skin changes, eczematoid changes, or severe edema.

Duplex quantitative VCT. Quantitative evaluation of venous valvular reflux was performed as described by van Bemmelen et al.[2] VCTs were measured at six locations: the saphenofemoral junction (SFJ), greater saphenous vein above the knee (GSV), lesser saphenous vein (LSV), superficial femoral vein (SFV), popliteal vein (PV), and profunda femoris vein (PFV). Scanning was performed with an ATL Ultramark 9 Duplex scanner (Advanced Technology Laboratories, Bothell, Wash.), and the segments were evaluated with the patient in the upright position with their weight supported on the contralateral leg. For evaluation of the SFV, the PFV, the SFJ, and the mid-GSV in the thigh, an automated 24-mm pneumatic thigh cuff was inflated to 80 mm Hg for approximately 3.0 seconds and then rapidly deflated within 0.3 seconds. For evaluation of the PV and LSV, a 12-cm cuff was applied to the calf, inflated to 100 mm Hg, and rapidly deflated. Both color-flow Doppler scanning and spectral analysis were recorded; the spectral analysis was used to quantify the amount of reflux. Not all patients underwent evaluation of all six venous locations. Early in the series we did not examine the PFV and LSV, and some patients had previously undergone ligation and stripping of superficial veins or thrombosed venous segments. Tibial veins were not studied. A normal-range VCT is 0.5 seconds or less, and reflux is considered present when the VCT is greater than 0.5 seconds.

Because not all patients had all segments evaluated, we separated the segments in the following manner: superficial 1 = SFJ + GSV; superficial 2 = SFJ + GSV + LSV; deep 1 = SFV + PV; deep 2 = SFV + PV + PFV; total leg 1 = superficial 1 + deep 1; total leg 2 = superficial 2 + deep 2 (all six segments). Reflux was considered present in either the superficial 1 or deep 1 category if the sum of the VCTs were greater than 1 second, and in the superficial 2 and deep 2 categories if the sum of the VCTs were greater than 1.5 seconds.

The presence of varicose veins was noted, but their size and distribution were not recorded, and the noted presence of varicose veins for a particular limb ranged from telangiectasias to dilated, bulging varicosities.

Statistics. Data analysis was performed on a personal computer with Star View 4.5 (Abacus Concepts, Berkeley, Calif.) Between-group differences were tested by analysis of variance and post hoc testing where appropriate. Significance was considered when p was 0.05 or less.

RESULTS

A total of 545 limbs underwent duplex scans for VCTs from January 1, 1992, to November 30, 1995. Data were incomplete concerning the clinical stage or the presence of varicose veins in 45 limbs; these limbs were excluded from the study, leaving 500 limbs available for analysis. Sixty-nine limbs were classified as clinical class 0, 149 limbs as class 1, 168 limbs as class 2, and 114 limbs as class 3. There was equal distribution between right and left limbs for classes 0, 1, and 2, whereas left limbs were predominant in class 3. Similarly, a vast majority of limbs in classes 0, 1, and 2 were female; however, this trend was reversed for class 3, in which male limbs predominated in a 1.6:1 ratio (Table I).

Varicose veins were noted to be present in 0% of class 0 limbs, 84% of class 1 limbs, 89% of class 2 limbs, and 46% of class 3 limbs (Table I). A history of ligation and stripping of varicose veins was found in 4% of class 0 limbs, 11% of class 1 limbs, 12% of class 2 limbs, and 29% of class 3 limbs.

Table I. Demographics

	Class 0	*Class 1*	*Class 2*	*Class 3*
Total no. (limbs)	69	149	168	114
Mean age (yr)	48.0	47.5	46.0	50.3
Limb (%)				
Right	37 (54)	73 (49)	85 (51)	48 (42)
Left	32 (46)	76 (51)	83 (49)	66 (58)
Sex (%)				
Male	15 (22)	32 (21)	50 (30)	70 (61)
Female	54 (78)	117 (79)	118 (70)	44 (39)
Varicose veins (%)	(0)	(84)	(89)	(46)

Table II shows the mean and median VCTs for individual segments, the subtotals for superficial and deep systems, and the limb totals according to clinical class. In class 0 limbs there was very little reflux in the superficial veins, with a mean value within normal for the lesser saphenous system. For class 1, 2, and 3 limbs, however, there was significant prolongation of the VCT at the SFJ, mid-GSV, and the LSV. The amount of superficial reflux was statistically significantly less in the asymptomatic limbs; however, there were no incremental differences in the amount of superficial reflux as the clinical class progressed.

Mean VCT reflux in the three deep veins that were examined showed a steady increase as clinical symptoms progressed, with the exception of PFV reflux in class 2 limbs. Of note is the statistically significant increase in reflux in both the SFV and PV that was seen in the ulcerated class 3 limbs compared with the nonulcerated limbs. The significant increase in reflux is even more pronounced when the median VCT values are considered (Table II).

There was also a steady increase in total limb reflux (TL1 and TL2) as clinical class progressed. Comparing total limb reflux (TL2) in classes 0, 1, and 2 in cases in which all six venous segments were examined, superficial reflux accounted for 83%, 91%, and 98% of total reflux, respectively. In class 3 limbs, superficial reflux accounted for only 54% of total limb reflux (Table II).

Reflux by venous system is illustrated in Table III. Because many limbs did not have all six venous segments examined, primarily because of thrombosis, previous surgical removal, or being tested early in the series, we excluded those limbs from this portion of the data analysis. Thus Table III includes all limbs, and only those limbs, that had complete tests performed in the superficial and deep systems. As expected, clinical class 1 had the highest incidence of isolated superficial reflux, because by clinical definition class 1 has isolated or generalized dilated superficial veins. Class 3 limbs had a 23% incidence of isolated deep system reflux, whereas both superficial and deep system reflux occurred in 37%. Thus there was involvement of the deep system in a total of 60% of class 3 limbs, compared with only 29% of class 2 limbs. There was no difference in the incidence of superficial system reflux among class 1, 2, and 3 limbs.

Examination of the deep system for solitary segmental reflux (Table IV) showed no significant difference in the incidence of solitary SPV or PV reflux as clinical class progressed. Class 3 limbs had a total incidence of PV reflux of 66.7%, compared with 34.4% in class 2 limbs. That difference was accounted for by the high degree, 52.8% in class 3 limbs, of combined axial SFV and PV reflux. Similarly, the incidence of SFV reflux showed a significant increase in class 3 limbs, mostly in combination with PV reflux.

Reflux in the GSV that originated below a competent SFJ valve was not statistically different in any of the clinical groups, ranging from 12% in class 2 limbs to 19% in class 1 limbs. Reflux in the lesser saphenous system was present in 5% of class 0 limbs, 38% of class 1 limbs, 45% of class 2 limbs, and 24% of class 3 limbs (Table V). Overall, when LSV reflux was present, there was concomitant GSV reflux in 58% of limbs, and no GSV reflux in 42%.

DISCUSSION

The study database is comprised of patients who were referred to the vascular laboratory for evaluation of venous reflux, primarily by the vascular surgery service but occasionally by other physicians. Tibial veins were not examined for reflux, both because of time constraints in the vascular laboratory and because of the nonsurgical nature of solitary-segment tibial reflux. Duplex evaluation of perforator incompetence is also not a routine part of the examination for venous reflux in our laboratory. As this was a review of clinical studies begun in 1992, data were not detailed for the revised reporting standards in venous disease,[1] and thus the limbs were graded in classes 0 to 3 according to the original reporting standards.[5] The

Table II. Mean (and median) VCTs for individual segments and systems, by clinical class

	Superficial			*Deep*		
	SFJ	*GSV*	*LSV*	*SFV*	*PFV*	*PV*
Class 0	0.5 ± 0.2* (0.1)	1.6 ± 0.4* (0.2)	0.3 ± 0.1† (0.1)	0.6 ± 0.2 (0.1)	0.1 ± .04 (0.1)	0.7 ± 0.2 (0.1)
Class 1	3.3 ± 0.3 (0.4)	5.6 ± 0.6 (5.1)	2.7 ± 0.5 (0.3)	1.0 ± 0.2 (0.2)	0.7 ± 0.2 (0.1)	1.4 ± 0.6 (0.2)
Class 2	3.7 ± 0.3 (3.2)	4.9 ± 0.4 (4.0)	3.9 ± 0.7§ (0.4)	1.4 ± 0.2 (0.2)	0.3 ± 0.1 (0.1)	1.9 ± 0.2 (0.2)
Class 3	3.3 ± 0.4 (3.3)	4.2 ± 0.4 (4.6)	1.6 ± 0.5 (0.1)	3.1 ± 0.3¶ (2.5)	1.0 ± 0.2 (0.2)	4.1 ± 0.4¶ (3.85)

VCTs in seconds ± SEM.
TS1, Total superficial 1 (see text); *TS2,* total superficial 2; *TD1,* total deep 1; *TD2,* total deep 2; *TL1,* total leg 1; *TL2,* total leg 2.
*$p < 0.01$ vs. class 1,2,3.
†$p < 0.05$ vs. class 1,2.
‡$p < 0.01$ vs. class 3.
§$p < 0.05$ vs. class 3.
||$p < 0.01$ vs. class 0.
¶$p < 0.001$ vs. class 0,1,2.

mean age of the current study group is consistent with that of previous reports, as is the gender distribution. Two possible explanations for the reversal of gender predominance in the class 3 patients are treatment compliance or the possibility that men do not seek medical attention until ulceration appears. There were no significant gender differences in measured VCTs.

There are several noninvasive methods to assess venous reflux, including photoplethysmography, air plethysmography, and duplex ultrasonography. Although our current practice frequently combines the latter two methods, especially in patients who have more severe CVI, we rely heavily on quantitative duplex scanning both to screen patients and to determine the anatomic location of the reflux. Although reports[6] have shown that Valsalva maneuver, manual compression, and cuff deflation can equally produce venous reflux, at least in the proximal veins, we believe that reflux is best tested for with the patient in the upright position using the cuff deflation technique described by van Bemmelen et al.,[2] which is both patient-independent and technician-independent.

Duplex ultrasound scans are widely used to assess venous reflux. Early reports[7] described insonation of the venous segments performed with the patient standing. van Bemmelen et al.[2] described the method of cuff deflation that we used in this study and its many advantages. In their study of 30 normal legs, they found that 95% of VCTs were less than 0.5 seconds. There were eight normal limbs that had prolonged VCTs in the SFV or PV; however, these were all solitary segments and the limbs had normal VCTs in the other segments. Sarin et al.[8] also used duplex scans to assess venous valvular function, although with the use of a different technique. With the patient standing to examine the groin and sitting to examine the lower leg, and using manual calf compression to elicit reflux, they found venous reflux in normal limbs to be 0.5 seconds or less in 119 of 120 segments examined.

We believe that the position of the patient is important when measuring venous reflux. Masuda et al.[6] found no significant difference between Valsalva maneuver in the reverse Trendelenburg position and standing cuff deflation in proximal venous reflux, but had to prolong the "normal" VCT in the common femoral vein to 1.5 seconds as "physiologic reflux" in Valsalva maneuver. They found the standing cuff deflation technique to produce higher velocities and sharper tracings in the PV when compared with Valsalva maneuver, and conceded that the standing cuff deflation technique may be superior at the PV site. Araki et al.[9] studied ultrasonic detection of PV reflux and found standing calf compression to be the best method of distinguishing PV reflux in normal and diseased limbs. Although they found no differences between pneumatic or manual compression, they did find that consistency was difficult with manual compression and concluded that pneumatic compression probably provides better standardization between laboratories. When comparing quantitative duplex scans with descending phlebographic evaluation, Masuda and Kistner[10] showed that a VCT greater than 0.5 seconds corresponded to phlebographic reflux. We have previously shown[4] that a combined SFV and PV VCT greater than 4.0 seconds corresponded to phlebographic reflux below the knee. The conclusions of that work are supported by the present study, which shows that deep segment reflux usually occurs in combination in class 3 limbs (Table IV). Baker et al.[11] and Neglen and Raju[12] found duplex scans to be more sensitive than de-

TS1	*TS2*	*TD1*	*TD2*	*TL1*	*TL2*
2.2 ± 0.5* (0.4)	3.4 ± 1.1† (0.7)	1.3 ± 0.4 (0.3)	0.8 ± 0.2 (0.4)	3.0 ± 0.5* (0.9)	4.2 ± 1.1* (1.4)
8.8 ± 0.8 (7.6)	10.6 ± 1.2 (9.0)	1.9 ± 0.3 (0.4)	2.2 ± 0.5 (0.6)	9.9 ± 0.9‡ (8.8)	11.8 ± 1.2 (9.3)
8.5 ± 0.7 (8.4)	11.5 ± 1.2 (11.9)	3.3 ± 0.3‖ (0.7)	2.6 ± 0.5 (0.8)	11.7 ± 0.8 (11.2)	12.0 ± 1.4 (12.3)
7.1 ± 0.7 (6.7)	7.4 ± 1.0 (6.9)	7.0 ± 0.5¶ (6.7)	6.5 ± 0.9¶ (4.3)	13.9 ± 0.9 (14.3)	13.4 ± 1.4 (14.5)

scending phlebographic scans in assessing reflux in chronically diseased limbs.

There is no controversy over the fact that venous reflux produces venous hypertension and thus the clinical changes seen in CVI. A number of studies have quantified venous reflux with air plethysmography or duplex scanning.[3,4,12-19] All of the studies show increasing reflux with progression of the clinical stage, although several did not reach statistical significance. Christopoulos et al.[16] showed that an increase in venous filling index as measured by air plethysmography corresponded to worsening clinical stage. Similarly, Welkie and associates[15] reported deterioration in all parameters measured by air plethysmography as the clinical stage progressed. Using duplex scans, Vasdekis et al.[3] found that a reflux velocity greater than 10 ml/sec was associated with a high incidence of skin changes. In a study similar to our current one, Weingarten and associates[14] quantified venous reflux with duplex ultrasonography and found the total limb reflux time to be significantly longer in patients who had ulcers compared with those who did not. A total limb reflux time of greater than 9.66 seconds was predictive of ulceration. Nicolaides[20] has shown that increased ambulatory venous pressure corresponds to an increased incidence of ulceration. Raju and Fredericks[13] calculated a "reflux index" based on foot venous pressures and also demonstrated an increased incidence of ulceration with increasing reflux index. Thus venous reflux is not an all-or-nothing phenomena, and more is worse.

There is, however, considerable controversy over the role of reflux in the superficial, deep, and perforator systems in the production of venous ulcerations. Results vary widely among published studies. Hanrahan and associates[21] performed duplex scans in limbs that had ulceration to identify venous reflux, including the perforator system, but they did not quantitate the reflux. They found isolated deep reflux in only 2.1% of limbs and a total incidence of deep system reflux of 49.5%. Although their 16.8% incidence of isolated superficial reflux compares with that from our current study, their 79% total incidence of superficial reflux is higher. They also had multisystem incompetence in 66.3% and no reflux in 6.8%. Interestingly, they found very little reflux in the SFV. A similar study was recently performed by Labropoulos et al.,[22] who examined 34 limbs that had ulcers. They found a 24% incidence of isolated superficial incompetence and a 6% incidence of isolated deep reflux, with a 91% overall incidence of superficial reflux versus 70% deep reflux. Two other studies[23,24] that examined ulcerated limbs with duplex scans found isolated superficial incompetence in 52% and 53%, respectively. These disparate results may reflect patient selection. As a tertiary referral center, our patient population is biased in that many have been treated by other physicians and surgeons before our consultation, particularly for class 2 and class 3 limbs.

Several studies have looked at reflux across the spectrum of CVI. Myers et al.[25] concluded that deep system reflux was not significant in ulcer formation because most of the limbs that had ulcers did not have deep reflux. Examination of their data, however, shows a steady increase in deep reflux as clinical stage progresses, with a similar decrease in isolated superficial reflux. Reflux in both superficial and deep systems increased as symptoms progressed, reaching significance between class 1 and class 3. Their statistical analysis was actually more significant for deep system progression than superficial. In addition, they also showed more multisegment deep reflux in ulcerated limbs versus nonulcerated limbs.

One other study has used quantitative duplex scans to measure VCTs, or reflux duration, in examining the deep and superficial systems. Weingarten et al.[14] found isolated deep system reflux in 51% of limbs with class 1 and 2 CVI, and a 72% incidence in limbs with class 3 CVI. As opposed to the present study, they did not find significant differences in venous segment reflux in limbs in classes 1 and 2 when compared with those in class 3. When they totaled the superficial and deep segments, however, their findings concur with the present study. Their mean total "reflux time" was 9.66 seconds in ulcerated limbs versus 7.44 seconds in nonulcerated limbs. When they

Table III. Reflux by venous system and stage in patients with all segments examined (%)

Class	No reflux	Superficial only	Deep only	Both	Superficial (total)	Deep (total)
0 (n = 11)	55	36	9	0	36	9
1 (n = 69)	25	56	5	14	56	19
2 (n = 45)	27	44	7	22	66	29
3 (n = 30)	17	23	23	37	60	60

Table IV, A. Incidence of popliteal vein reflux by clinical class

Clinical class	Solitary PV reflux	PV + SFV reflux	Total PV reflux
0	6.1%	3.0%	9.1%
1	6.7%	6.7%	13.4%
2	15.9%	18.5%	34.4%
3	13.9%	52.8%	66.7%

Table IV, B. Incidence of superficial femoral vein reflux by clinical class

Clinical class	Solitary SFV reflux	SFV + PV reflux	Total SFV reflux
0	10.6%	3.0%	13.6%
1	12.7%	7.4%	20.1%
2	15.9%	18.5%	34.4%
3	12.0%	52.8%	64.8%

Table V. Greater saphenous and lesser saphenous reflux

Class	Competent SFJ/incompetent GSV (%)	LSV reflux (%)
0	16	5
1	19	38
2	12	45
3	14	24

isolated the deep system "reflux time," it was significantly greater, 6.38 seconds versus 5.18 seconds, in the ulcerated limbs. Conversely, there was no difference in the superficial system: 6.24 seconds in ulcerated limbs versus 6.32 seconds in nonulcerated limbs.

There is no doubt that superficial incompetence plays a significant role in many patients who have venous ulceration, upwards of 53% in some studies.[24] The value of quantitative duplex is apparent in that it can noninvasively identify those patients who can be successfully treated with ligation and stripping of the affected superficial veins. This is why we obtain VCTs for most patients who come to us with venous disease and for all patients who have ulcers.

The role of perforating veins in the formation of venous ulcers has been called into question. We do not routinely examine the perforators for reflux when we obtain VCTs, but we image them independently when ulcers are suspected on clinical examination and when we are considering subfascial ligation. Without data, we can not comment on the contribution of perforators in our patient population.

Deep venous reflux is a significant contributor to symptom progression in CVI. Neglén and Raju[19] showed an incidence of deep reflux in 29%, 82%, and 94% of limbs in class 1, 2, and 3, respectively. Others[14,18,25] have also shown increasing deep system reflux with clinical progression. Shull et al.[26] showed that incompetence of the PV valve was the most important factor in elevated ambulatory venous pressures and ulcerations. The findings in this study emphasize the importance of deep venous reflux in symptom progression and ulcer formation. Involvement of the deep system steadily increased along the clinical classes, with a notable increase from 29% to 60% between class 2 and class 3. Conversely, once symptoms were present there was no difference in the incidence of superficial reflux (classes 1 to 3). This is further supported by quantitating the degree of reflux. With one exception (LSV, class 2 vs class 3), there was no difference among clinical classes in the amount of superficial reflux. More significantly, there also was no progression in the degree of superficial reflux at any location or in combination (SFJ, GSV, LSV, TS1, TS2) as clinical class worsened. Quantitation of reflux at the level of the SFV and PV do show a steady increase along the clinical spectrum, with a highly significant increase in those limbs that had ulcers. The median values at these levels, which will diminish the effect of extremely prolonged individual VCTs, also emphasize the significant contribution of axial deep venous reflux ulcer formation. This finding is supported by an earlier study by Burnand et al.,[27] who found ulcer recurrence within 5 years after ligation of incompetent perforators in all patients who had deep system abnormalities on phlebographic evaluation, compared with a 6% recurrence rate in patients who had a normal deep system.

There is concern by some that 0.5 seconds may not be an appropriate cutoff to define abnormal reflux.[28] Other authors have considered reflux of 1.0 second or less to be normal, although not with the standing cuff deflation technique.[29] We therefore examined the present data a second time using a VCT greater than 1.0 second as abnormal.

There were no changes in the overall percentages of reflux. As an example, there were 72 class 3 limbs that had PV reflux greater than 0.5 second. Of the 72 abnormal PV VCTs, only three were between 0.5 and 1.0 second, and the remaining 69 had a VCT greater than 1.0 second.

In the present study, total limb VCTs increased with clinical progression but did not reach statistical significance. The incidence of combined superficial and deep system reflux also progressed (Table III). Several other studies have shown an increase in multisystem reflux in limbs that have ulceration.[8,11,14,18,25,30]

Incompetence of the LSV has previously been shown to contribute to ulcer formation.[21,31] We did not see this effect in the current study, in which there was an increase in LSV reflux in class 1 and 2, but a decrease in class 3. Similarly, reflux in the PFV will maintain elevated ambulatory venous pressures in otherwise corrected deep venous reflux.[32] In this study, although there was significantly more reflux in the PFV in class 3 compared with class 0 and class 2, the amount of PFV reflux in class 1 was not different. Thus we cannot conclude that PFV reflux contributes to ulceration.

Knowledge of the location and degree of venous reflux is mandatory in the clinical management of patients who have CVI. It is evident from this study and others[29] that reflux in individual limbs may occur in either the superficial or deep systems alone or in combination. Quantitative duplex VCT can aid in the preoperative decisionmaking, procedure selection, and feasibly, prognostication. One would expect good long-term results with surgery on the superficial system in the presence of no or minimal reflux in the deep system. On the contrary, the results of this study suggest that the surgeon consider deep system reconstructive surgery in those patients who have recalcitrant ulcers.

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