

Relationship Between Reflux and Greater Saphenous Vein Diameter

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ABSTRACT Purpose: Quantitative algorithms to select patients for stripping, ligation, or banding require additional data on greater saphenous vein (GSV) diameter and valvular function. Although the final goal is to determine whether reverse flow, or reflux, is due to valvular damage, valvular absence, or vein enlargement with normal valves, this study was a first step in quantifying the influence of venous enlargement as a potential cause of reflux. Methods: Color flow ultrasound venous evaluation was performed in 100 extremities of 65 women and 14 men with primary varicose veins. Greater saphenous vein diameters measured at the junction with the common femoral vein, in the thigh, and in the calf were compared for two groups: veins with significant reflux (defined as peak reflux velocity >30 cm/sec or duration >0.5 sec) and veins without significant reflux. Accuracy and positive (PPV) and negative (NPV) predictive values for reflux were calculated for 1 mm diameter increments. Results: Differences in diameters of veins with significant reflux versus veins without reflux, 7.7 ± 2.3 (SD) mm (n=46) versus 5.7 ± 1.3 mm (n=54) at the junction, 5.5 ± 2.0 mm (n=57) versus 3.3 ± 1.2 mm (n=43) in the thigh and 3.5 ± 1.4 mm (n=41) versus 2.5 ± 0.6 mm (n=59) in the calf, were statistically significantly different (p=0.000, t-test). Best accuracies for predicting reflux at the junction, thigh, and calf, 71, 75, and 74%, respectively, were achieved with diameter thresholds equal to or greater than 7, 4, and 4 mm with corresponding PPV of 73, 81, and 89% and NPV of 70, 69 and 70%. For diameters equal to or greater than 9, 7, and 5 mm at the junction, thigh, and calf, respectively, PPV=100% were achieved. Conclusions: Saphenous vein diameter was a significant factor in valvular insufficiency with significant reflux. In a mixed population, a single diameter criterion accurately predicted reflux in about 70% of the extremities. Diameter thresholds with probable certainty to cause reflux were found. These findings may influence selection of treatment alternatives.

Introduction

The surgical treatment for varicose veins has been changing significantly in recent years. Surgeons and patients have concerns about cosmetic results and saphenous preservation for future cardiac or peripheral arterial bypasses. The availability of noninvasive techniques in general and color flow duplex ultrasonography have permitted anatomical and functional evaluation of the deep, communicating, and superficial venous systems.¹⁻⁴ Selective surgery, individualized for each patient, is now possible with avoidance of unnecessary saphenous vein stripping. The greater saphenous vein can be preserved entirely or segmentally. This approach may have a long-term benefit of bypass conduit availability. Immediate benefits of this simplified surgical procedure, however, are less trauma, decreased postoperative

morbidity, and improved venous function.

Quantitative algorithms to select patients for saphenectomy, ligation, or banding require additional data saphenous vein diameter and valvular function. General goals for this research program are: (1) to develop algorithms associating reverse flow, or reflux, to valvular damage, valvular absence, or vein enlargement with normal valves and (2) to develop criteria for exclusion of sources of reflux while preserving the saphenous vein. With these objectives in mind, this study was a first step toward quantifying the influence of large venous diameters as a potential cause of reflux in a population concerned with the cosmetic appearance of their lower extremities.

Methods

Patient Population

Color flow ultrasound evaluation of the superficial veins was performed in 100 extremities of 79 patients. There were 65 women and 14 men. The mean age was 30 years (18-64 = range).

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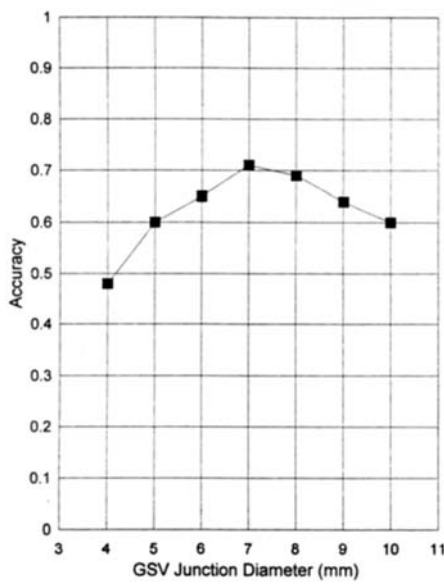


Figure 1

Reflux prediction accuracy.

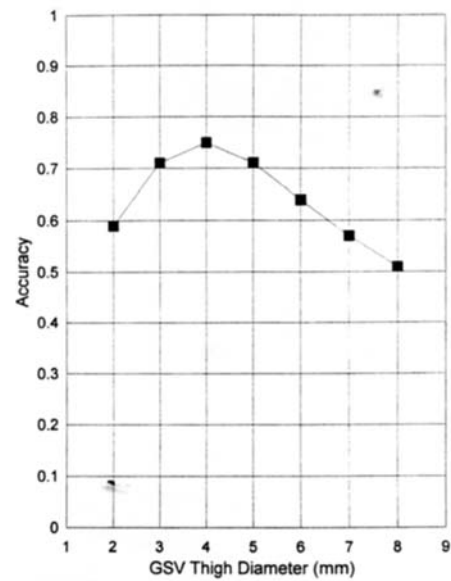


Figure 2

Reflux prediction accuracy.

All patients were referred to the vascular laboratory for preoperative assessment prior to varicose vein surgery. None had clinical signs of deep venous thrombosis or leg ulcers.

Diameter Measurements

All patients were evaluated with color flow duplex ultrasound in a warm room, usually at the end of a work day. With the patient supine, a 5-MHZ transducer was used to rule out chronic or recent deep venous thrombosis. With the patient standing, a 7-MHZ transducer was used to measure greater saphenous vein (GSV) diameters. Measurements were performed in cross-sectional B-mode images at different levels: sapheno-femoral junction at the groin; upper, mid-, and distal thigh; knee; and upper, mid-, and distal calf. Thigh and calf measurements were averaged for analysis.

Reflux Detection

Using color flow imaging in the longitudinal view, the saphenous valvular function was evaluated at the femoral junction, thigh, and calf levels. Flow direction was noted during Valsalva maneuver and proximal and distal muscular compressions. Reflux was quantified based on maximum reverse velocity and/or valve closure time from the Doppler spectral tracings obtained in longitudinal section. Reflux was considered significant if peak velocity greater than 30 cm/sec or a valve closure time greater than 0.5 sec was detected.⁴⁻⁵ Sources of reflux routinely examined in the groin were the sapheno-femoral junction, pelvic veins, and greater saphenous accessories and tributaries. In the thigh, saphenous accessories, tributaries, and perforating veins, primarily Dodd's and Hunter's, were investigated as potential sources of reflux. Branches from lesser saphenous vein and perforating veins, primarily Cockett's and Boyd's,

were evaluated as reflux sources in the calf. Reflux patterns are described in the Appendix.

Statistics

Group differences. GSV average diameters (1) at the junction with the common femoral vein, (2) in the thigh, and (3) in the calf were compared for two groups: Group I, veins with significant reflux, and Group II, veins without significant reflux. Averages were compared using a Student's t-test.

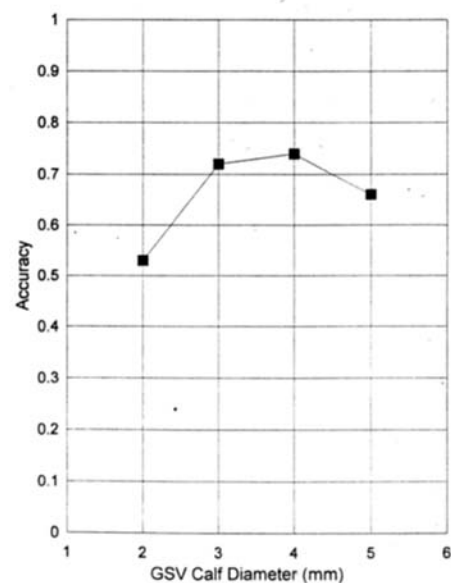


Figure 3

Reflux prediction accuracy.

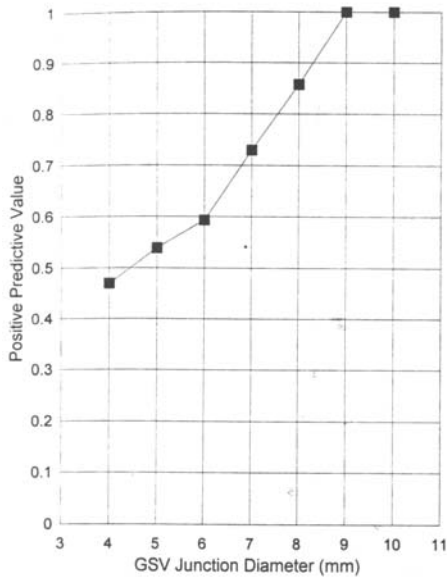


Figure 4

Reflux positive predictive values.

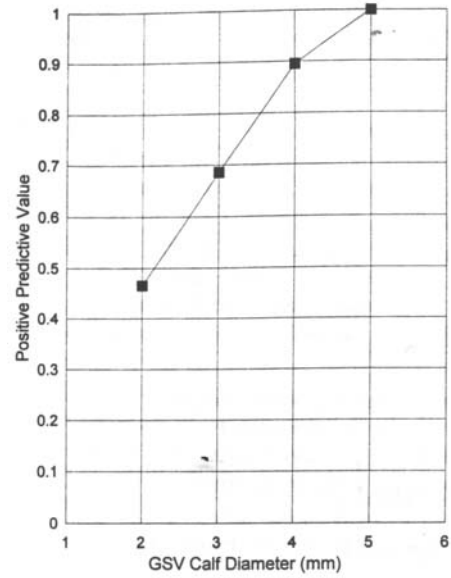


Figure 6

Reflux positive predictive values.

Reflux prediction. Probability of reflux given by predictive accuracy, positive predictive value (PPV), and negative predictive value (NPV) were calculated as a function of GSV diameters at the femoral junction, thigh, and calf levels.

Results

Table I lists the average GSV diameters as a function of reflux. Greater saphenous vein diameters ranged from 2.7 to 14.0 mm at the femoral junction, 1.5 to 12.0 mm in the thigh, and 1.3 to 8.0 mm in the calf. On average, GSV diameters

decreased by 2 mm from the junction to the thigh and then from the thigh to the calf. At the junction and the thigh, veins with reflux were 2 mm larger in diameter than veins without reflux. At the calf level, the difference in diameter between veins with and without reflux was less, 1 mm. These differences were statistically significant by t-test.

Accuracies to predict reflux based on GSV diameters are depicted in Figures 1-3. At the junction, a 7-mm diameter threshold had the best accuracy (71%) for predicting reflux (equal to or greater than 7 mm had reflux, less than 7 mm corresponding to no reflux). In the thigh, the best accuracy for

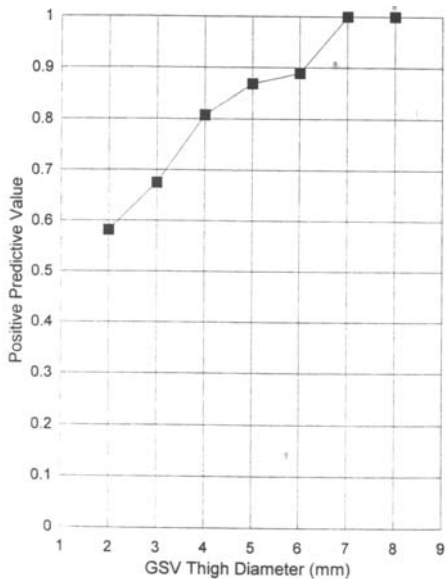


Figure 5

Reflux positive predictive values.

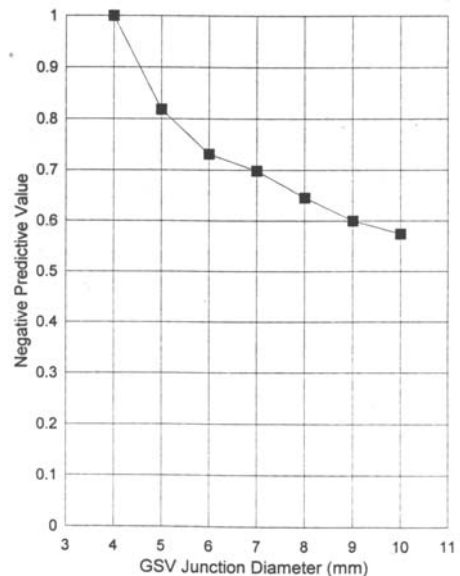


Figure 7

Reflux negative predictive values.

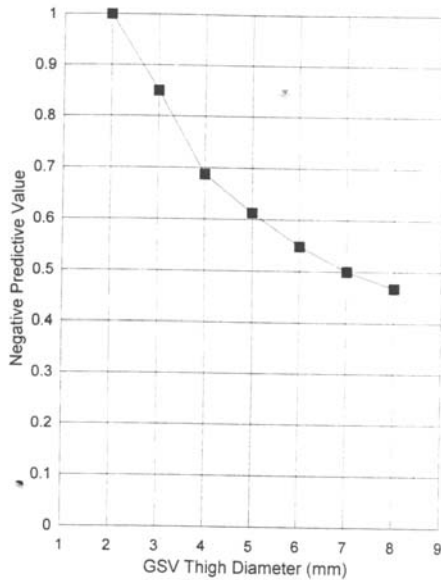


Figure 8

Reflux negative predictive values.

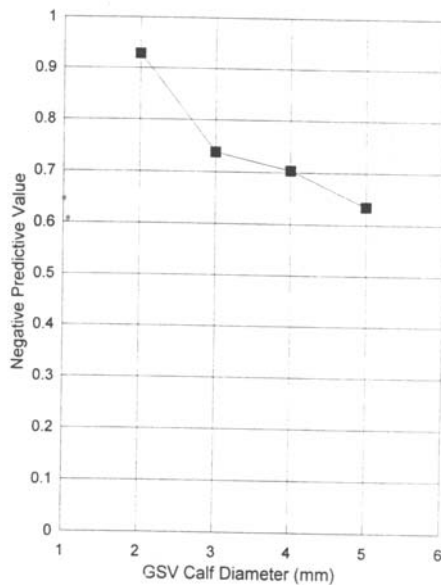


Figure 9

Reflux negative predictive values.

Table I

Greater Saphenous Vein Diameters

Location	Severe reflux		No/mild reflux		p value*
	n	Diameter (mm)	n	Diameter	
Junction	46	7.7 ± 2.3	54	5.7 ± 1.3	0.000
Thigh	57	5.5 ± 2.0	43	3.3 ± 1.2	0.000
Calf	41	3.5 ± 1.4	59	2.5 ± 0.6	0.000

* Student's t-test.

predicting reflux (75%) was achieved with a 4-mm diameter threshold. In the calf, a 4 mm-diameter threshold also gave the best accuracy for predicting reflux (74%). The corresponding PPV for the 7-mm threshold at the junction and 4-mm thresholds at the thigh and calf were 73, 81, and 89%, respectively, and the NPV were 70, 69, and 70% for veins smaller than these thresholds.

Positive and negative predictive values are shown in Figures 4-6 and 7-9. At the junction, all veins with 9 mm or more had reflux (n = 10). At this level, 18 of 22 veins with less than 5-mm diameter had no reflux. In the thigh, all 14 veins with diameters equal to or greater than 7 mm had reflux. The majority of veins with less than 3-mm diameter (17 of 20) did not have reflux. In the calf, almost all veins with diameters of 4 mm or more had reflux (17/19). With one exception (13/14), veins with less than 2-mm diameter had no reflux.

Discussion

Varicose vein surgery has grown, with great demands for excellent cosmetic results. Because the saphenous vein is often treated in conjunction with varicectomy, informed patients have inquired about the saphenous vein value as a conduit for cardiac or peripheral bypasses. Besides leg appearance or future bypasses, we now have a growing awareness of functional or clinical outcome after treatment, and remaining saphenous vein segments may benefit venous function. These concerns have led to increased saphenous vein preservation in connection with varicose vein treatment.

The saphenous vein can be preserved totally or segmentally. Saphenous vein banding or ligation at the femoral junction has been performed successfully.⁶ If the sources and drainages of reflux are complex (see Appendix), individual surgery is planned accordingly. It is beyond the scope of this paper to discuss treatment algorithms in detail. Treatment options, however, have been selected empirically. We have yet to define quantitative methods to determine, for example, if banding or ligation will be successful in eliminating reflux or in reducing vein diameter. Which of these two goals is more important? This is an important question without a quantitative answer. We still must investigate differences between residual or recurrent reflux after treatment and welcome reverse flow that maintains the saphenous vein intact. It is also fundamental to separate conditions of valvular damage from venous enlargement as a cause of reflux. As a first step in this quantification process, we investigated the relationship between diameter and reflux observed preoperatively.

An important technical consideration is that venous enlargement with daily activities and standing may cause reflux. In normal veins of young, healthy subjects, daily activities may not affect valvular function significantly.⁷ As venous elasticity degenerates, however, reflux appearance may follow conditions affecting venodilation. The patients included in this study were evaluated under conditions favoring the occurrence of reflux. Exercise, a warm environment, and standing favor venodilation. Greater saphenous vein diameters measured were compatible with literature data measured in similar conditions.⁷ These values may be slightly larger than values obtained during saphenous vein mapping in search for infrainguinal bypass conduits.⁸⁻¹⁴

That reflux would be more frequent in large veins is common knowledge. This numerical analysis quantified such a general concept. For example, based on the average diameter difference for the two groups, with and without reflux, a 2-mm dilation of the veins could cause reflux. Conversely, it should be possible to eliminate reflux if venous compression with stockings or venous banding reduced the diameter by 2 mm.

We also have determined that certain specific diameter thresholds, 9 mm at the junction, 7 mm in the thigh, and 5 mm in the calf, are markers for certainty of reflux. A question yet to be answered is whether such large veins are damaged and therefore inadequate for cardiac or peripheral bypasses. Another question to be considered is whether banding or ligation can decrease such large diameters significantly to improve patient well being.

On the other side of the spectrum, minimum diameters correlate with lack of reflux, particularly diameters less than 5 mm at the femoral junction and less than 3 mm in the thigh. These veins ought to be preserved. In the calf, it has become apparent that reflux is a more complex issue. In the midrange of diameters, reflux is relatively unrelated to diameter and individual evaluation helps direct treatment.

In summary, venous diameter is significantly related to reflux, as expected. We obtained specific large diameters that are associated with a very high probability of reflux. We also determined specific small diameters associated with virtual lack of reflux, particularly at the femoral junction and thigh. Finally, the effect of therapy on venous diameter must be evaluated to create quantitative algorithms for saphenous vein preservation, either for arterial bypass or improved venous function, and to better understand the differences between valve damage or valve dysfunction due to venous dilation.

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Appendix

Greater Saphenous Vein (GSV): Reflux Patterns		
Type	Reflux source	Reflux drainage
0	None	None
I	GSV: none Tributaries	GSV: none Tributaries
II	Femoral junction branches Femoral junction (GSV)	Varicose branches Perforating veins
III	Perforating vein Varicose branch	Distal GSV with reflux
IV	Perforating vein Varicose branch	Perforating vein Varicose branch
V	Diffuse GSV reflux	Diffuse

In types 0 and I, the GSV is not involved; in type II, GSV has reflux only proximally; in type III, GSV has reflux only distally; in type IV, GSV has reflux segmentally; and in type V, the entire GSV is involved.