The importance of deep venous reflux velocity as a determinant of outcome in patients with combined superficial and deep venous reflux treated with endovenous saphenous ablation

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Introduction: **Twenty to thirty percent of patients with symptomatic chronic venous insufficiency (CVI) are found to have combined superficial and deep venous reflux on duplex testing. It is currently unclear whether endovenous ablation (EVA) of the saphenous vein will result in correction of CVI without addressing the deep venous reflux. In this study, we examined deep venous reflux velocities to determine whether these would predict outcome after endovenous ablation.**

Methods: **Patients with symptomatic CVI and both saphenous and deep venous reflux were identified using duplex ultrasonography. Reflux times and maximal reflux velocity (MRV) in each examined vein segment were determined. In each limb, the venous filling index (VFI) and the venous clinical severity score (VCSS) were obtained both before and after laser ablation of the great and/or small saphenous veins. Preoperative venous reflux velocities were correlated with improvement in VFI and VCSS after ablation.**

Results: **75 limbs with both deep and superficial venous reflux were identified. Seventy-five percent of limbs were CEAP clinical class 3 or 4 and the other 25% were class 5 or 6. Forty limbs demonstrated deep venous reflux in the femoral and/or popliteal vein. After EVA, significant improvements in VFI and VCSS were seen, but this depended on MRV in the deep vein. When MRV in the popliteal or femoral vein was <10 cm/sec, limbs had significantly better outcomes than limbs with MRV >10 cm/sec as measured by both VFI ($P = .01$) and VCSS ($P = .03$). In 35 limbs, deep venous reflux was identified only in the CFV. In this group, the average pre-procedure VFI (6.54 ± 3.9 cc/sec) decreased significantly to 2.2 ± 1.9 cc/sec ($P < .001$) and the VCSS improved markedly from 7.0 ± 2.8 to 1.3 ± 1.4 ($P < .001$).**

Conclusions: **EVA of the saphenous veins can be performed in patients with concomitant deep venous insufficiency with hemodynamic and clinical improvement in most cases. Patients with popliteal or femoral reflux velocities lower than 10 cm/sec usually experience marked improvement in both the VFI and the VCSS. Patients with femoral or popliteal reflux velocities greater than 10 cm/sec have a high incidence of persistent symptoms after EVA. (J Vasc Surg 2008;48:400-6.)**

INTRODUCTION

Patients with symptomatic chronic venous insufficiency (CVI) commonly are affected by abnormal venous reflux in both the deep and superficial systems. In patients with class 5 and 6 CVI, 27.5% of patients were reported to have combined disease[1] and in another study, 22% of limbs with primary superficial venous reflux also displayed reflux in the deep system.[2] Physicians commonly recommend removal or ablation of the great and/or small saphenous veins to treat symptomatic CVI for superficial reflux. Infrequently, deep venous reconstruction is considered for patients with deep venous reflux, usually in patients with severe symptoms recalcitrant to less invasive attempts at treatment. It is currently difficult to predict whether patients who are found to have both deep and superficial reflux will improve if only the superficial reflux is addressed.

While some authors have reported deep venous reflux resolution after saphenous vein stripping procedures,[3,4] others have reported poor clinical outcomes after saphenous removal in the presence of deep venous insufficiency.[5] We have recently observed that patients with superficial reflux commonly display low velocity reflux in the deep veins, most often in the popliteal segment, that persists longer than 0.5 seconds, satisfying the criteria for deep venous reflux. The clinical significance of this low velocity reflux is not well described.

Recently, endovenous methods of saphenous ablation (EVA) have supplanted stripping procedures as the most common method of eliminating saphenous reflux.[6,7] Using radiofrequency or laser energy sources, EVA has been found to reliably ablate the great or small saphenous vein resulting in improved venous hemodynamics and control of venous symptoms.[8]

The objective of this study is to determine whether preoperative duplex criteria such as the deep venous reflux velocity are predictive of hemodynamic and clinical outcome after EVA of the saphenous vein(s) in patients with combined deep and superficial venous insufficiency.

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METHODS

Study design. Retrospective review of prospectively collected case series.

Approval. This study was approved by the Biomedical Institutional Review Board at the University of North Carolina School of Medicine.

All patients with symptomatic CVI found to have both deep and superficial reflux who were treated with endovenous saphenous ablation were included in this study. Abnormal venous reflux was determined using duplex ultrasound within a well documented protocol. Preoperatively, supine and standing reflux studies were performed to map sites of venous reflux. Duplex ultrasonography was performed with the patient in a supine position, using 30 degrees of reverse Trendelenburg. Commencing at the saphenofemoral junction, the deep, superficial, and perforating veins were assessed with Doppler scan flow patterns and B-mode imaging as previously described.[9] Compression maneuvers and examination of flow patterns with augmentation were utilized to identify the presence of either acute or chronic venous obstruction and to determine the patency of the venous outflow tract.

Venous reflux in the deep and superficial venous systems was evaluated while the patient was in a standing position, with their weight shifted to the contralateral limb. A rapid inflation/deflation system (Hokanson E20 Rapid Cuff Inflator and AG101 Cuff Inflator Air Source, Issaquah, Wash) and duplex ultrasound scan were used for this examination. Systematic interrogation of the common femoral, femoral, popliteal, great saphenous, and small saphenous veins was conducted measuring valve closure times. A cutoff valve closure time of 0.5 seconds was the criterion for significant venous reflux for both the deep and superficial venous systems. Perforating veins that were >3.5 mm in size at the fascial level and demonstrated at least 0.5 seconds of outward flow on compression and release of the calf were defined as incompetent.[10]

The maximal reflux velocity (MRV) in the deep venous system was determined for the common femoral, femoral, and popliteal veins by examining the reflux velocity tracings. The first 0.5 seconds of the reflux tracing were disregarded because the initial tracing reflected reflux prior to valve closure and frequently included artifact in the signal. Beginning at 0.5 seconds after cuff release until the end of the reflux recording, the location of the highest velocity of reflux was identified on the digital ultrasound record (see Fig 1). Using the ultrasound's digital cursor, the velocity corresponding to this maximal reflux was determined. For each waveform, the MRV can be measured in less than 15 seconds by an experienced vascular technologist.

Venous hemodynamics were assessed using an air plethysmograph (ACI Medical, Inc., Sun Valley, Calif). The venous volume (VV) was measured initially, and reflux into the calf was determined with calculation of the venous filling index (VFI) as previously described by Christopolous et al.[11] Three to six weeks after saphenous ablation, patients were restudied with duplex to define the anatomic success of

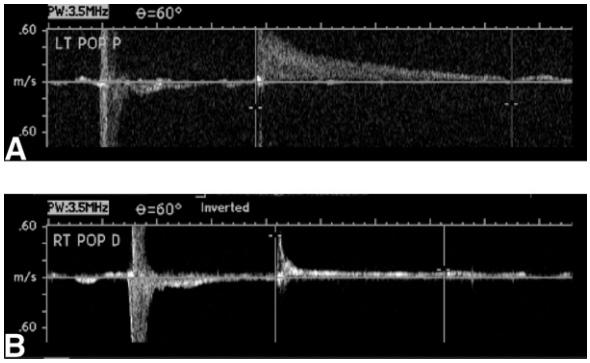

Fig 1. Measurement of maximal reflux velocity (MRV). In both images, cuff release occurs at the first vertical line. The x-axis is time with the large hash marks indicating 1 second. At 0.5 seconds after cuff release, the velocity of reverse flow (in cm/sec) is identified and recorded as MRV. **A,** High velocity reflux in the popliteal vein of 38 cm/sec. **B,** Low velocity reflux in the popliteal vein of 8 cm/sec.

ablation and with APG to determine whether the VFI corrected after the procedure. The anatomic outcome of saphenous ablation was described as complete if the saphenous vein was ablated with no flow from within 5 cm of the saphenofemoral junction (SFJ) to the knee, partial if the saphenous vein was ablated with no flow from 5-10 cm distal to the saphenofemoral junction to the knee, and unsuccessful if flow was present in segments greater than 10 cm distal to the saphenofemoral junction.

Venous clinical severity scores (VCSS) were measured at the patient's initial clinic evaluation and after saphenous ablation at the 3-6 week follow-up visit. Subsequent VCSS were measured during clinic visits at 6-month intervals. Scoring was tabulated as described previously with a maximum score of 30.[12]

EVA was performed utilizing an 810 nm laser source and 600 um laser fiber as previously described.[13] Micropuncture catheter/guidewire sets were used for GSV access at or just below the knee. Sheath and laser fiber introduction cephalad to the saphenofemoral junction was performed under ultrasound guidance. The target to initiate laser therapy was between 1 and 1.5 cm distal to the SFJ. Peri-vein tumescence was performed utilizing saline containing lidocaine and sodium bicarbonate over the entire length of GSV to be treated. Laser energy was delivered at 14 watts and catheter pullback was continuous with the rate targeted at one centimeter each 5-6 seconds to apply 70-80 joules of energy per cm of vein treated.

Ablation of varicose veins was performed immediately after EVA if necessary using powered transilluminated phlebectomy as previously described. Limbs were compressed with layered bandaging or compression hose and were discharged fully ambulatory. Compression was maintained for 2-4 weeks but was discontinued if the postoperative studies revealed normal APG parameters.

Statistical analysis. Comparisons between pre- and post-EVA VFI and VCSS within groups were performed

Table I. CEAP criteria

Clinical class	3	4	5	6
Number limbs	49	7	14	5
Etiologic class	Primary		Secondary	
Number limbs	62		13	
Pathophysiology	Reflux alone		Obstruction alone	Both
Number limbs	68		None	7

Table II. Distribution of reflux in segments of the deep venous system

Segment	*Number of limbs*
CFV alone	35
FV alone	0
PV alone	21
CFV and FV	6
CFV and PV	8
CFV, FV, and PV	5

using paired Student's t-tests.[14] Comparisons between the VFI and VCSS after EVA in limbs with high MRV compared with low MRV in the deep venous system were performed using both parametric and non-parametric methods. Modified t-tests (Satterthwaite) comparing the means of VFI and VCSS in these two groups were conducted and nonparametric tests were conducted to confirm significance in which the outcome was dependant on normalization of the VFI or reduction of the VCSS to less than two. The association between the two dichotomous variables was tested using Chi-square analysis. Correlation coefficients were obtained using standard Pearson regression analysis.

RESULTS

Between January 2004 and March 2007, 75 limbs in 70 patients with both deep and superficial reflux on duplex ultrasound examination were treated with EVA. The distribution of saphenous reflux involved the great saphenous vein in 71 of 75 limbs and the small saphenous in 14 of 75 limbs. During this same time period, 261 limbs with superficial reflux alone were treated with EVA. The average patient age was 57 years and 70% were female. CEAP classification is detailed in Table I. There are no clinical class two patients because we have not recommended intervention for patients with multisystem venous reflux who did not have clinical class three or greater symptoms. The anatomic distribution of abnormal deep venous reflux is detailed in Table II. Using our definition, incompetent perforators were identified in eight limbs (11%). No limbs were treated with perforator ligation or ablation.

Outcome in all 75 limbs. The average preoperative VFI in the entire group was 6.37 ± 3.9 cc/sec. and the average VCSS was 7.0. EVA was performed on the GSV alone in 61 cases, the SSV alone in four cases, and both in 10 cases. Ablation of prominent varicosities with powered phlebectomy was performed in 58 cases (77%). EVA resulted in closure of the treated saphenous veins in 74 of 75 cases with one GSV found to have persistent flow in the proximal 12 cm in the proximal thigh and occlusion of the more distal segment of the vein.

Table III. Pre- and postoperative VFI measured by air plethysmography in patients treated with EVA of the superficial system with high versus low preoperative deep venous reflux velocity in the femoral or popliteal vein

	VFI before EVA	*VFI after EVA*	P *value before vs after EVA*
Low MRV	5.4 ± 2.3	2.2 ± 2.3	<.001
High MRV	6.9 ± 4.7	4.4 ± 3.2	.007
P value low vs high MDRV	NS	.01	

VFI, Venous filling index; *MRV,* maximal reflux velocity in the femoral or popliteal vein; *EVA,* endovenous ablation.

Table IV. Pre- and postoperative VCSS in patients treated with EVA of the superficial system with high versus low preoperative deep venous reflux velocity in the femoral or popliteal vein

	VCSS before EVA	*VCSS after EVA*	P *value before vs after EVA*
Low MRV	7.1 ± 2.1	1.6 ± 0.9	<.001
High MRV	8.2 ± 2.7	3.5 ± 3.5	<.001
P value low vs high MDRV	NS	.03	

VCSS, Venous clinical severity score; *MRV,* maximal deep reflux velocity in the femoral or popliteal vein; *EVA,* endovenous ablation.

Post-ablation follow-up for at least six months was obtained in 57 limbs (76%). Median follow-up time was 13.1 months. All patients completed their initial follow-up at 3-6 weeks with measurement of post-procedure VFI and VCSS for inclusion in endpoint analysis. In the entire group, EVA resulted in a significant improvement in venous hemodynamics with the post-procedure VFI falling to 2.67 ± 2.3 cc/sec ($P < .01$). A significant improvement in VCSS was also noted with the median VCSS at the last follow-up visit of 1.9 ± 2.2 ($P < .001$).

Limbs with deep reflux in the femoral and/or popliteal veins. In 40 limbs, deep venous reflux was noted in the femoral and/or popliteal veins. The VFI before EVA in this group of patients was markedly abnormal (6.2 ± 3.8) and improved significantly after EVA to 3.3 ± 3.0 ($P < .001$). The VCSS before EVA (7.7 ± 2.5) also improved significantly after EVA to 2.6 ± 2.7 ($P < .001$). This improvement was dependant on the MRV in the most distal deep venous segment displaying abnormal reflux. The most distal segment was the femoral in six limbs and the popliteal in 34 limbs. If the MRV in this most distal refluxing deep vein was >10 cm/sec, the improvement in VFI and VCSS were significantly less than in limbs where the MRV in the distal deep venous segment was <10 cm/sec (Tables III and IV). Limbs were significantly more

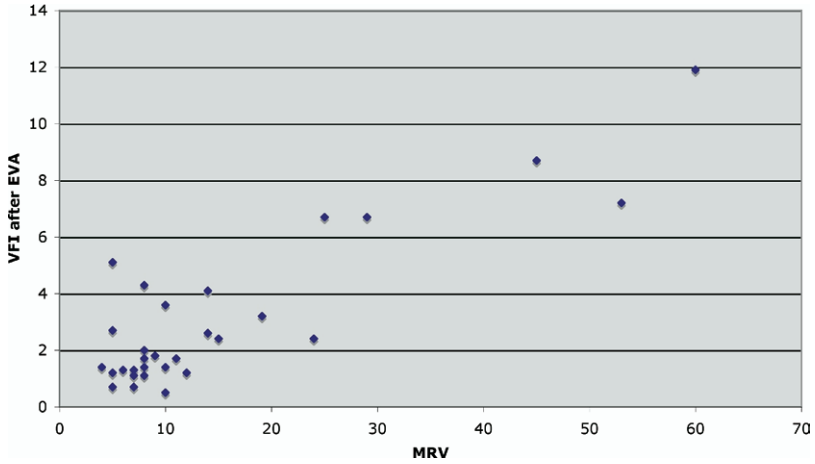

Fig 2. Correlation between pre-ablation Maximal Reflux Velocity (MRV) and post-ablation venous filling index (VFI) in limbs with GSV reflux and femoral and/or popliteal reflux (limbs with SSV reflux removed).

likely to experience correction of the VFI to the normal range when the preoperative MRV was <10 cm/sec (15 of 19 limbs) than when the preoperative MRV was >10 cm/sec (five of 21 limbs, P = .01 by Chi square test). The correlation coefficient between preoperative deep vein MRV and the postoperative VFI was 0.55. There were three outliers with high MRV who experienced correction of the VFI and VCSS after EVA. These limbs were found to have had high velocity reflux in the popliteal vein and SSV that was treated with EVA of the SSV, which likely resulted in correction of the popliteal reflux. After removing limbs treated with EVA of the SSV from analysis, the correlation coefficient between deep vein MRV and post-procedure VFI was 0.87 ($P < .01$, Fig 2). In the group of limbs with high deep venous MRV who did not undergo EVLA of the SSV, only one of 15 limbs experienced normalization of the VFI after EVLA of the superficial system. Of note, even in the group with high MRV in the deep venous system, significant improvement in the VCSS was noted after EVLA, but the post procedure VCSS was significantly higher than in limbs with a low deep venous MRV (Table IV).

Limbs with deep reflux limited to the common femoral vein. Thirty-five limbs were identified with superficial reflux and deep venous reflux confined to the common femoral vein. In this group, the VFI decreased significantly after EVA ($P < .001$) and the VCSS improved significantly after EVA ($P < .001$) as represented in Fig 3. The MRV in the CFV was not related to outcome because 29 of 35 limbs experienced resolution of their venous hemodynamics with a normal VFI and only four patients in this group reported a VCSS greater than two at follow-up visits.

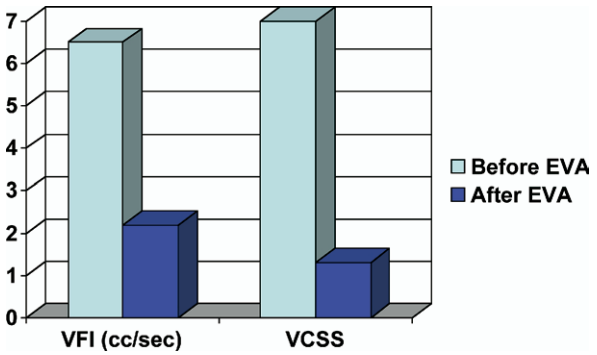

Fig 3. Venous filling index (VFI) and Venous Clinical Severity Score (VCSS) before and after endovenous ablation (EVA) in patients with saphenous reflux and deep venous reflux in the common femoral vein ($P < .001$ for both VFI and VCSS).

DISCUSSION

Patients presenting with chronic venous insufficiency are frequently found to display reflux in both the deep and superficial venous systems. In the current series of patients undergoing endovenous ablative procedures, this anatomy was identified in 22% of limbs. EVA is a relatively low risk procedure that may be performed in an office setting under local anesthesia with a typically short recovery time.[6,7] Procedures that are currently utilized to correct deep venous insufficiency such as valve repair or valve transfer techniques are more invasive procedures requiring a longer recovery time yielding variable results.[15] Most physicians treating patients with combined superficial and deep venous insufficiency would consider initial ablation of the superficial system without addressing the deep venous reflux. In patients with persistent symptoms after superficial ablation, deep venous reconstruction can then be considered.

The identification of criteria predictive of symptomatic improvement after saphenous ablation alone would aid significantly in the management of this group of patients. Those with criteria predictive of improvement may proceed to EVA while those with criteria predictive of persistent symptoms after EVA may wish to consider other treatment options, or if they proceed with EVA, it is with the knowledge that symptoms may persist despite the procedure.

Padberg and colleagues reported a hemodynamic follow-up of 11 limbs with deep and superficial disease treated with superficial stripping and perforator ligation in some cases.[16] Although only 27% of limbs studied postoperatively were found to have correction of deep venous reflux, marked hemodynamic improvement was demonstrated. The venous filling index decreased from 12 ml/sec preoperatively to 2.7 ml/sec postoperatively, and clinical symptom scores decreased from 10 to 1.4. The majority of limbs in this study displayed primarily proximal reflux. These and other authors have reported that patients with superficial and deep reflux isolated to the common femoral vein will experience correction of the deep venous reflux after superficial venous ablation. This occurs due to the lack of valves in the common femoral vein in most limbs. Therefore reflux in the GSV results in reflux in the more proximal common femoral from tributaries up to a competent iliac vein valve.

When considering deep venous reflux involving the femoral and popliteal veins, there is contradictory information concerning the ability of superficial ablation to correct deep venous reflux. Walsh et al and Sales et al reported resolution of deep venous reflux after GSV stripping in over 90% of cases,[3,4] but Scriven et al reported that deep venous reflux usually did not correct after superficial stripping.[5] Adam et al reported that deep venous reflux confined to either the femoral or popliteal segments corrected in 50% of limbs after superficial venous surgery, and limbs with ulcers healed in 77% of cases.[17] Puggioni et al recently reported a study of 38 limbs with combined deep and superficial reflux studied with duplex ultrasound before and after saphenous stripping.[18] Deep venous reflux was corrected in one third of patients, and femoral vein reflux corrected more frequently when only segmental reflux was present in that vein rather than axial reflux throughout the deep venous system. The authors concluded that superficial ablative procedures rarely improve deep venous reflux in limbs with axial reflux and that further long-term study is required to determine the effects of superficial procedures on the deep venous system.

In their methodology, Puggioni et al describe a classification system for peak reflux velocity in the deep venous system, but did not report that this correlated to outcome after superficial venous ablation.[18] We have elected to define MRV at 0.5 seconds after release of compression because many vein segments will display a brief initial high velocity burst of reflux prior to valve closure. We believe that measuring the MRV at the time that persistent reflux is defined as abnormal eliminates spuriously elevated values generated by the diagnostic test itself. It is possible that other methods of defining venous reflux in the deep venous segments may yield better predictive results such as an average velocity of reflux over time as proposed by Delis et al for the evaluation of perforator reflux.[19] This and other potential predictors will be evaluated in ongoing studies.

There exists some disagreement concerning the definition of abnormal deep venous reflux with some authors using 0.5 seconds as the cutoff for abnormal reflux and others using 1 second as the cutoff. We have used 0.5 seconds as our definition and in this series only three limbs were included with a reflux value between 0.5 and 1 second in the deep venous segment. Reviewing the results without these three limbs included, we found no significant changes in the findings of the statistical review.

In this study we elected to measure outcomes using the VFI and VCSS. The VFI as measured by air plethysmography has been validated as a reproducible measure of the severity of CVI.[11] The VFI has also been found to predict the long-term symptomatic outcome for patients after venous surgical procedures. Owens et al reported that 94% of patients in whom the VFI corrected to <2 ml/sec immediately after venous surgery were asymptomatic at a mean follow-up time of 44 months.[20] The VCSS was developed as a clinically relevant measure of disease severity and has been found to be useful in reflecting changes in the severity of venous insufficiency after venous procedures.[21,22] In Meissner et al's report validating the VCSS, it was found to correlate well with CEAP clinical class allowing definition of absent venous disease (VCSS score <3), mild to moderate disease (4 to 7), and severe (>8) disease categories.[23] We elected to use these measures rather than repeating duplex scanning of the deep venous segments to provide information on clinically relevant outcomes. Although it would have been interesting to see whether deep venous reflux was abolished or persistent from a scientific standpoint, this means little if clinically relevant measures do not improve.

The results of this analysis agree with those of previous authors who have noted correction of common femoral vein reflux after great saphenous removal. Similarly, with EVA, our patients experienced correction of the VFI in most cases with a corresponding decrease in VCSS to an average of 1.3 after EVA. In the absence of FV or PV reflux it appears that CFV reflux is benign and should not affect the potential for benefit from superficial venous ablation.

Patients with deep venous reflux in the femoral and/or popliteal veins were less likely to completely correct their venous hemodynamics as measured by VFI after superficial venous ablation. However, there was improvement in this parameter as well as the VCSS in most patients. We found that the MVR in the most distal refluxing deep vein, popliteal or femoral, was predictive of outcome after EVA as measured by VFI and VCSS. The association was particularly strong when patients with prominent reflux in the SSV were removed from analysis. Prominent SSV reflux is likely to increase the duration and velocity of reflux in the popliteal vein, even if the valve proximal to the saphenopopliteal junction is competent. It is important to measure reflux in the popliteal vein distal to the saphenopopliteal junction to minimize this variable, but this is not always possible given the anatomic variability of the junction. We were not able to verify the location of measurement of popliteal vein reflux in all cases so it is possible that some were measured above the junction yielding spuriously high velocities.

Limbs with a high MRV and no SSV reflux pre-ablation were rarely found to normalize the VFI and VCSS post-ablation, although some experienced a modest improvement in these parameters. Patients with a low pre-procedure MRV experienced significantly better outcomes with a lower VFI

and fewer post-procedure symptoms. The MRV may be useful to evaluate options for patients with combined deep and superficial disease. Those with a low MRV can be counseled that EVA is likely to result in improvement or correction of their symptoms, while those with an unfavorable MRV can be counseled prior to intervention that they may have persistent symptoms after ablation allowing them to consider other therapeutic options.

Further study of deep venous tracings in a larger group of patients is required to confirm the information presented here. It must be acknowledged that the number of patients with popliteal or femoral reflux and great saphenous reflux is relatively limited (n = 28) and analysis with a larger sample size may yield stronger associations. Longer clinical follow-up would also be useful to determine the durability of the results after EVA in this patient population. We also have not yet evaluated the effect of venous outflow obstruction or incompetent perforators on reflux velocities in the femoral and popliteal veins. It is possible that correction of outflow obstruction or perforator incompetence in patients with distal deep reflux may result in decreased MRV as a source of symptomatic improvement.

CONCLUSIONS

EVA of the saphenous veins can be performed in patients with concomitant deep venous insufficiency with hemodynamic and clinical improvement in most cases. Patients with femoral or popliteal MRV lower than 10 cm/sec usually experience marked improvement in VFI and VCSS. Patients with femoral or popliteal reflux velocities greater than 10 cm/sec in the absence of SSV reflux have a high incidence of persistent symptoms after EVA.

AUTHOR CONTRIBUTION

Conception and design: WM, WB, RM, MW
Analysis and interpretation: WM, WB, RM, DB, BK
Data collection: WM, WB, DB, MW
Writing the article: WM, DB
Critical revision of the article: WM, WB, RM, MW, BK
Final approval of the article: WM, WB, RM, DB, MW, BK
Statistical analysis: WM, DB, BK
Overall responsibility: WM

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DISCUSSION

Dr. Cynthia Shortell (Durham, NC). I would like to start by commending Dr. Marston and his colleagues on an extraordinarily thoughtful, well-organized, and scientifically sound paper about a highly relevant topic to those of interested in venous disease. Specifically, the authors address the relevance of deep reflux in the setting of the treatment of superficial reflux. In the 1990s, Dr. John

Bergan was one of the first people to identify the fact that some deep reflux can be corrected by treating superficial reflux. While a large percent is corrected, there are a significant number of patients with deep reflux in whom superficial ablation does not correct their deep reflux. In this paper, Dr. Marston and his colleagues finished that thought very nicely by identifying the means by which patients who will improve and those that will not can be differentiated. I do have a few questions for the authors. First of all, duplex evaluation does not provide optimal evaluation of iliac vein involvement; and specifically one is concerned about iliac vein obstruction, and you did mention a significant number of your patients had a secondary etiology. Albeit infrequently, this can play a significant role in looking at infrainguinal reflux and its presence changes the management of this problem markedly. How do you decide in your practice whether or not to look for iliac vein lesions such as stenosis and occlusion and how often is this necessary in your opinion? Next, in the manuscript I was surprised to see that you didn't specifically discuss perforator status on your patients. Do you routinely look for them, and what role do you think perforators play in the improvement of symptoms and the change in VFI after ablation? Specifically, do you think that the treatment of perforators ever changes a high MRV to a low MRV? I was wondering if that might be a way to change the prognosis for some of those high MRV patients. I was interested in the fact that you treat all patients with varicose veins at the time of your EVA; we actually do a staged treatment. I was wondering if that reflected the fact that you were in the camp that believes all patients with varicose veins should have them removed if they are large because they serve as a later reservoir for reflux and they contribute to recurrence, or whether this was more of a convenience of practice protocol. I also wanted to know how hard the measurement of MRV was for a non-academic lab as most venous labs are. Is it something that could readily be applied in general practice so that the non-academic practitioners could use this as a way of differentiating the appropriate from the nonappropriate patients, although one wonders if that is something that one wants to do. Then, what is your follow-up protocol? You addressed this a little bit in one of your slides. Do you use the VCSS and the VFI as sort of a screening tool to do follow-up duplex? We know that a significant number of patients will progress or recur after treatment and I was wondering if you do any routine follow-up duplex of the entire venous system or only as clinical symptoms warranted. Lastly, I was interested in knowing what your personal practice is now. Do you offer ETA with patients with the high MRV? What is your percentage of indication for deep venous intervention, what sort of intervention do you use? Have you had any experience with percutaneous valves?

Dr. William Marston. Thank you Dr. Shortell for those insightful comments. We do look for iliac vein obstruction and perforator involvement in all limbs with venous insufficiency. Since Drs Raju and Neglen have educated us on the frequency of iliac involvement, we have become more aggressive in looking for and treating iliac outflow obstruction. Our thoughts on incompetent perforators have been well documented in the past in a study in which we found that the majority of incompetent perforators are no longer incompetent after superficial surgery and varicosity ablation alone. So our preference is to treat the superficial disease first, and if the perforators remain, we will treat them later. We have not yet studied the effect of iliac vein stenting or perforator ablation on MRV, but I think that is an excellent question. I personally like to take the varicosities for the more severe patients, the classes 4-6, and get all those out of there up front. For less severely affected patients, you can manage the varicosities however you want based on your practice situation and your patients' preferences. The MRV is not a difficult measurement to make and if you just look at the reflux waveforms instead of just looking at a report, it is easy to tell the difference between a low and high MRV. It is an easy measurement for the vascular technologists to do and it doesn't take much time, less than 20 seconds per tracing. Basically, my practice now is to always consider ablating the superficial system in patients with combined deep and superficial disease as it is possible to get some improvement even in the severe cases. But I think it is really important to tell the patients ahead of time that if they have a high MRV it is possible that their symptoms may not improve entirely. You might need to perform further intervention to correct their symptoms. In higher risk patients with combined disease and a high MRV, it may be better to avoid superficial intervention as there is a lower chance of symptomatic improvement.