Editors' Choice

Ultrasound-based topographic analysis of tributary vein connection with the saphenous vein during ambulatory conservative hemodynamic correction of chronic venous insufficiency

Sangchul Yun, MD, PhD, RPVI, RVT, *Seoul, Korea*

CME Activity

Purpose or Statement of Need The purpose of this journal-based CME activity is to enhance the vascular specialist's ability to diagnose and care for patients with the entire spectrum of circulatory disease through a comprehensive review of contemporary vascular surgical and endovascular literature.

Learning Objectives

- Locate the common sites of tributaries in patients with saphenous incompetence
- Know where to remove venous tributaries at their junction with the saphenous vein to prevent recurrence

Target Audience This activity is designed for vascular surgeons and individuals in related specialties.

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ABSTRACT

Objective: Preoperative mapping of great saphenous vein (GSV) escape points to tributary veins (TVs) and targeted intervention of escape points may reduce recurrence rates of varicose veins (VVs) after endovascular treatment of saphenous veins and prevent saphenous nerve complications. The aim of this study was to perform an analysis of cartography after Doppler ultrasound mapping of escape points in patients with VVs and to suggest one point that may prevent recurrence and nerve complications.

Methods: Ultrasound assessment of VVs was performed from March 4, 2016, to July 15, 2016, specifically focusing on the locations of escape points from the saphenous vein to TVs. The collected data were reviewed retrospectively. The topographic distribution of escape points was as follows: from inguinal ligament to midthigh; from midthigh to knee; from knee to midcalf; and from midcalf to heel.

Results: Thirty patients (41 legs) with VVs underwent ultrasound examination. All VVs were characterized by reflux at the GSV. Topographic analysis revealed a total of 79 escape points in all patients. The most common location for escape points was the third part of the leg (from knee to midcalf), where 65.8% of escape points were located; 82.3% of all escape points were located below the knee. The mean diameter of the GSV at 3 cm and 15 cm from the saphenofemoral junction was 6.8 ± 1.6 cm and 5.5 ± 1.5 cm, respectively. Mean diameter of TVs was 5.1 ± 1.9 cm. The diameter was not significantly different between saphenous veins and TVs. The mean number of escape points in each leg was 1.9 ± 1.0.

From the Department of Surgery, Soonchunhyang University Seoul Hospital.
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Correspondence: Sangchul Yun, MD, PhD, RPVI, RVT, Department of Surgery, Soonchunhyang University Seoul Hospital, 59, Daesakwan-ro, Yongsan-gu, Seoul, Republic of Korea, 04401 (e-mail: ultravascsurg@gmail.com).
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Conclusions: Most escape points (65.8%) are located from knee to midcalf (third part of the leg), and 82.3% of all escape points are located below the knee. The diameter of TVs near the escape point is about 90% of that of the GSV. Thermal ablations of below-knee saphenous vein have potential nerve damage. Ablation of saphenous veins above the knee alone may result in residual shunting and formation of persistent reservoirs in TVs. These persistent reservoirs may be removed effectively with sclerotherapy or miniphlebectomy, especially trying to remove TVs near the escape point. Direct ligation of a TV near the escape point from the saphenous vein, just like saphenofemoral junction ligation, could be performed. These approaches may be able to prevent residual shunting and may reduce recurrence rates and nerve injury. (J Vasc Surg: Venous and Lym Dis 2019;7:356-63.)

Keywords: Varicose veins; Ultrasound; Saphenous vein; Recurrence; CHIVA

Endovascular treatment is preferred for varicose veins (VVs) along with radiofrequency ablation and endovenous laser ablation (EVLA), which have been assigned a 1B recommendation in the guidelines of the Society for Vascular Surgery and the American Venous Forum.[1] However, the high VV recurrence rate remains a problem.[2] To reduce the recurrence rate, adequate preoperative mapping and more targeted surgical intervention should be performed. During endovascular treatment, the efficacy and safety of frequently used interventions from the great saphenous vein (GSV) up to knee level have been questioned. After EVLA of the proximal GSV, 51% of patients with untreated below-knee GSV (BK-GSV) varicosities are found to have persistent reflux and only partially improved symptoms. Meanwhile, up to 89% of the patients needed some form of additional treatment for persistent varicosities.[3] Although EVLA has been recommended as safe for BK-GSV, it has often been reported that thermal damage cannot be prevented completely. Additional treatment with stripping procedures for BK-GSV has also been questioned, and 52% (12/23) of VV recurrence after surgery was related to an incompetent BK-GSV.[3] Therefore, a method is needed to treat BK-GSV to reduce any remaining reflux and nerve damage.

Another therapeutic approach, Cure Conservatrice et Hémodynamique de l'Insuffisance Veineuse en Ambulatiore (CHIVA [ambulatory conservative hemodynamic correction of venous insufficiency]), is based on a hemodynamic concept. The principle of this procedure is to treat venovenous shunting with ligation of the escape points while preserving the veins and maintaining venous outflow in the lower limb. A Cochrane investigation demonstrated a further reduction in the rate of VV recurrence after a CHIVA procedure compared with traditional ablative therapy.[4] To obtain optimal results with CHIVA, a comprehensive Doppler study is necessary to determine the hemodynamic pathologic process causing VVs. The recurrence rate after CHIVA is reportedly lower than that after VV stripping.[5-7] Hemodynamic correction could also be combined with endovascular treatment. Therefore, one possible way to reduce recurrence is through preoperative ultrasound examination to determine the hemodynamic pathologic process causing VVs.

According to the CHIVA concept, a shunt is the connection between three different networks, that is, from N1 to N2 or N3 and from N2 to N3.[8] Although preoperative ultrasound is frequently used in the treatment of VVs, most studies have reported findings (reflux from N1) such as reflux at the saphenofemoral junction (SFJ) or saphenopopliteal junction.[9]

Although the recurrence rates for EVLA are reasonable and not high and those experienced physicians treating below-knee reflux have done so very well, thermal ablation can be damaging to the saphenous nerve with resulting chronic pain. This study analyzed the topographic distribution of escape points from N2, the saphenous vein, to N3, tributary veins (TVs), in patients with primary VVs, investigating all possible patterns of reflux in the superficial venous system that might influence therapeutic strategies.

METHODS

Ultrasound VV assessment was performed from March 4, 2016, to July 15, 2016, specifically focusing on the location of escape points from the saphenous vein to a TV (EPSTs). The collected ultrasound data were reviewed retrospectively. The following were included: patients older than 20 years with VVs and GSV reflux. The following were excluded: patients with anterior accessory saphenous vein and small saphenous vein varicosities and those with limited normal walking, pregnancy, pelvic venous reflux, history of deep venous thrombosis, deep vein insufficiency, and previous VV surgery. Thirty consecutive patients with varicosities in 41 limbs were enrolled. This study was approved by the local Institutional Review Board. Consent of individual patients was waived because of the retrospective nature of the analysis. The study was performed according to the principles of the Declaration of Helsinki.

During the clinical examination, classification of VVs was determined according to the Clinical, Etiology, Anatomy, and Pathophysiology (CEAP) classification.[10]

Ultrasound assessments were performed by a registered vascular technologist. A high-frequency linear multifrequency transducer (ACUSON NX3; Siemens Healthcare GmbH, Erlangen, Germany) was used for the assessments. The competence of the deep venous system was assessed from the common femoral vein up to the tibial-peroneal trunk with the patient in a standing position. The superficial venous system was observed to assess competence, presence of reflux, and distribution of the saphenous vein and TV. Reflux was defined as inverse flow at the rate of >0.5 second with a Valsalva maneuver, Paraná maneuver, or squeezing maneuver. The GSV caliber was measured at approximately 3 cm and 15 cm from the SFJ. To identify venovenous shunts, the Teupitz classification was used.[11] The number and location of EPSTs were assessed, and the TV calibers were measured at <1 cm from the escape point. The Union Internationale de Phlébologie consensus considered GSV diameter at the proximal thigh 15 cm distal to the groin a potential surrogate parameter for chronic venous insufficiency,[8,12] so the diameter of the TV was compared with the diameter of the GSV at 15 cm from the SFJ. After venous mapping, the escape points and re-entry points as well as the type of shunt were represented with cartography. The location of an EPST was identified according to four topographic parts[13]: from the inguinal ligament to the midthigh, from the midthigh to the knee, from the knee to the midcalf, and from the midcalf to the heel.

Statistics were performed using SPSS version 15 software (SPSS Inc, Chicago, Ill). The patients' demographics are presented as percentage or mean ± standard deviation. The correlation with the various demographic factors (sex, age group, hypertension, CEAP class) was performed to see any difference in the numbers or locations of the escape points in any subgroups. The number of escape points was compared using paired *t*-test or analysis of variance. The location of escape points was analyzed using χ^2 test or Fisher exact test. The significance was defined as a *P* value <.05.

Definitions. According to the Union Internationale de Phlébologie consensus on lower limb venous anatomy, three different compartments are recognized on the basis of their relationship to the muscular fascia.[8,14] Venous networks in the lower extremity are delimited by two venous fasciae including the muscular or deep fascia and the superficial or venous fascia. N1 (primary network) lies deep to the muscular fascia. N2 (secondary network) lies between both fasciae and includes the GSV or small saphenous vein, anterior saphenous vein, and Giacomini veins. N3 (tertiary network) includes veins located outside the superficial fascia, such as branches of the saphenous vein and TVs.[14] Blood normally flows from the most distal veins in the lower extremity toward the heart and from the most superficial compartment (N3) toward the deepest compartments (N2 and N1). All three networks are connected by perforating veins, physiologically draining from N3 to N2 and then to N1 (Fig 1). In this context, an escape point is defined as an anatomic location where venous reflux occurs and blood is drained from a deeper to a more superficial compartment. For example, an EPST is the point of connection of a TV with the GSV (N2 to N3) because venous drainage flows from the deeper compartment (N2) toward the more superficial network (N3).

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective cohort study
- **Key Findings:** In 41 limbs of 30 patients, duplex ultrasound mapping showed that 82% of escape points from refluxing saphenous veins to tributary veins (EPSTs) were located below the knee, and a mean of 1.9 ± 1.0 EPSTs were found per leg. Tributary veins near escape points had mean diameters of ∼90% of the great saphenous vein.
- **Take Home Message:** Patients having above-knee thermal saphenous vein ablations should have treatment of EPSTs below the knee with sclerotherapy, miniphlebectomy, or direct ligation of tributary veins to prevent residual venous shunting and to reduce recurrences while minimizing the potential of saphenous nerve injury.

Pathologic reflux into a vein from the deep to superficial compartments is always associated with a re-entry perforating vein or re-entry point draining back into the deepest compartment.[15] For example, in the case of an incompetent SFJ with a refluxing GSV (pathologic flow from N1 toward N2), the re-entry point is a perforating vein that connects the GSV to the deep (N1) network and drains refluxing blood back toward the deep compartment.

Shunt type was classified on the basis of the point of reflux and re-entry of reflux flow according to the Teupitz classification[11]:

Shunt type I: Reflux source of the saphenous vein is the deep system (femoral or popliteal vein). The reversed flow drains back into the deep vein from the saphenous vein through a perforator vein without involving TVs (N1 → N2 → N1).

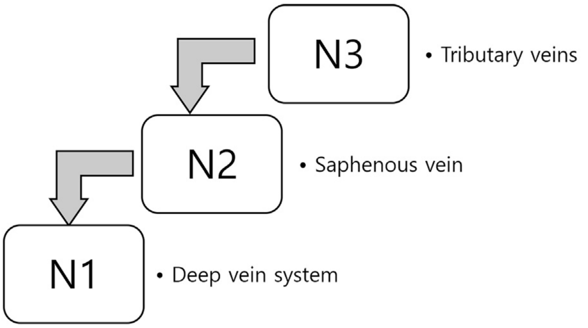

Fig 1. Blood normally flows from the most superficial compartment (*N3*) toward the deepest compartments (*N2* and *N1*). Venous reflux occurs when blood is drained from a deeper to a more superficial compartment.

Shunt type II: Reflux source into a TV is the saphenous vein. Re-entry is through the same saphenous vein or a perforating vein or another saphenous vein. There is no reflux from the deep system (N2 → N3 → N2 or N1).
Shunt type I + II: The pure form of type I has no refluxing tributaries. Type I + II is a combination of type I and type II having refluxing tributaries.
Shunt type III: Reflux source of the saphenous vein is the deep system (femoral or popliteal vein). Reflux flow through the saphenous vein and TV drains back into a perforator vein or saphenous vein. In contrast to shunt type I, a sufficient draining perforator does not present in the refluxing segment of the saphenous vein (N1 → N2 → N3→ N1).

RESULTS

During the study period, 30 patients (41 legs; 15 men, 15 women; age range, 26-73 years; mean age, 50.8 ± 12.6 years) with VVs underwent Doppler ultrasound mapping. No patient had previous VV surgery, current pregnancy, or deep vein reflux. All VVs were characterized by reverse flow at the GSV. CEAP-based distribution of venous disorders revealed C2 in 12 (26.8%), C3 in 7 (12.2%), and C4 in 11 (61.0%) patients without ulcers. The baseline characteristics, Venous Clinical Severity Score, and Aberdeen Varicose Vein Questionnaire score are presented in Table I. There were no significant correlations of the numbers or location of the escape points with demographic factors (sex, age group, hypertension, and clinical class).

According to the CHIVA strategy, shunt type was classified as type I in 2 (4.9%) patients, type II in 5 (12.2%), type I + II in 9 (21.9%), and type III in 25 (61%; Table II).

From topographic analysis, a total of 79 EPSTs were detected in all patients. Regardless of the shunt type, the most common location for EPSTs was the third part of the leg (from the knee to the midcalf), where 65.8% of EPSTs were located; 82.3% of all EPSTs were located below the knee (Table III; Fig 2).

During the Doppler examination, reverse flow was observed in the GSV in all patients. The mean diameter of the GSV at 3 cm and 15 cm from the SFJ was 6.8 ± 1.6 cm and 5.5 ± 1.5 cm, respectively. Mean diameter of TVs at 1 cm from the connection with the GSV was 5.1 ± 1.9 cm. At 15 cm from the SFJ, the ratio of the TV to GSV diameter was 0.9 ± 0.3. The mean number of EPSTs in each leg was 1.9 ± 1.0 (Table IV).

DISCUSSION

The aim of this study was to perform an analysis of cartography after Doppler ultrasound mapping in patients with VVs and to suggest one point that may prevent the recurrence and complications of venous disorders. In this study, the most common location for EPSTs was reported in the third part of the leg (from the knee to the midcalf) after topographic analysis, and 65.8% of EPSTs were located in this part, regardless of shunt type; 82.3% of all EPSTs were connected with the BK-GSV (Table III). The mean diameter of TVs near the connection with the GSV was 5.1 ± 1.9 cm, which was about 90% of the diameter of the GSV at midthigh level. This suggests that the most significant superficial venous reflux in TVs occurred from the BK-GSV. When significant EPSTs are detected below the knee, we have to treat them with an effective modality to reduce recurrence (Fig 2). However, laser heat during ablation of the BK-GSV could affect the saphenous nerve.

In conventional surgery, stripping of the saphenous vein, ligation of perforating veins, and multiple phlebectomies are performed, although usually for very large VVs. Neovascularization is considered the most common cause of recurrence.[16] In recurrent cases, there is no

Table I. Demographic analysis of 30 patients with varicose veins (VVs)

Characteristics	Values
Women	15 (50)
Age, years	50.8 ± 12.6
Diabetes	1 (3.3)
Hypertension	6 (20)
Weight, kg	65.2 ± 11.7
Height, cm	165.8 ± 8.5
BMI, kg/m^2	23.6 ± 3.0
CEAP class	
C2	12 (40.0)
C3	7 (23.3)
C4	11 (36.7)
DVT history	0 (0)
Deep vein reflux	0 (0)
Time for cartography, minutes	24.3 ± 9.2
VCSS	4.5 ± 1.8
AVVQ score	12.7 ± 9.2

AVVQ, Aberdeen Varicose Vein Questionnaire; *BMI,* body mass index; *CEAP,* Clinical, Etiology, Anatomy, Pathophysiology; *DVT,* deep venous thrombosis; *VCSS,* Venous Clinical Severity Score.
Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.

Table II. Shunt classification according to Cure Conservatrice et Hémodynamique de l'Insuffisance Veineuse en Ambulatoire (CHIVA) strategy used to treat 41 varicose veins (VVs)

	No. (%)
Right lower limbs	22 (53.7)
Shunt type	
Type I	2 (4.9)
Type I + II	9 (21.9)
Type II	5 (12.2)
Type III	25 (61.0)

Table III. Topographic analysis of the number of escape points from a saphenous vein to a tributary vein (EPSTs, the location of the connection between great saphenous vein [GSV] and tributary veins [TVs] having reflux)

Parts of leg	Shunt I + II (n = 9), No. (%)	Shunt II (n = 5), No. (%)	Shunt III (n = 25), No. (%)	Total, No. (%)
First part	0	0	2 (3.6)	2 (2.5)
Second part	2 (15.4)	4 (40)	6 (10.7)	12 (15.2)
Third part	8 (61.5)	6 (60)	38 (67.8)	52 (65.8)
Fourth part	3 (23.1)	0	10 (17.8)	13 (16.5)
Total	13	10	56	79

The pure form of shunt type I has no refluxing tributary veins, so type I shunt is not included in this table.

detectable location of reflux because of the lack of drainage after previous stripping and phlebectomy. Treatment of such cases is complex.[6] In cases of GSV stripping above the knee, reflux will persist in the BK-GSV and TVs postoperatively. A prospective study of 59 patients who underwent short stripping of the GSV revealed that the incidence of reflux in the BK-GSV slightly increased from 81% before surgery to 91% 2 years after surgery. The mean diameter of GSV below the knee increased between 6 months and 2 years after surgery, along with worsening clinical signs and symptoms.[17] Increased diameter of the saphenous vein means increased venous reservoir capacity.

In an endovenous treatment group, the clinical data suggested that residual reflux in the BK-GSV leads to increasing symptoms and more severe signs, with a

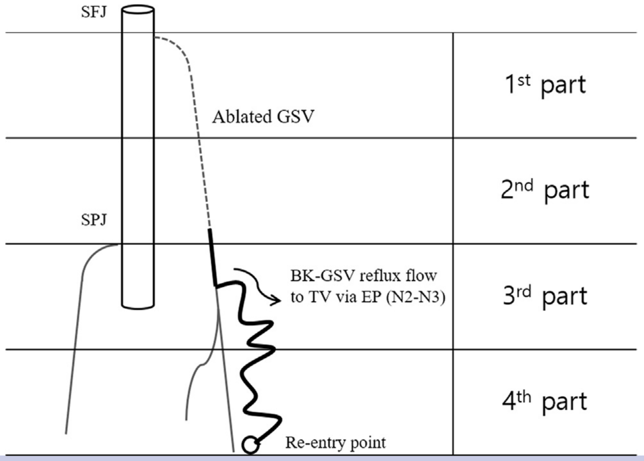

Fig 2. Based on topographic analysis, regardless of the shunt type, the most common location for an escape point (*EP*) from the saphenous vein to a tributary vein (EPST) was the third part of the leg, where 65.8% of EPSTs were located, and 82.3% of all EPSTs were connected to the below-knee great saphenous vein (*BK-GSV*). This suggests that most significant superficial venous reflux at tributary veins (*TVs*) occurred from the BK-GSV. Extended treatment from the BK-GSV up to the connection with the TV may be needed to reduce the potential for recurrent development of an escape point. *GSV,* Great saphenous vein; *SFJ,* saphenofemoral junction; *SPJ,* saphenopopliteal junction.

greater likelihood of residual and recurrent VVs.[18] A study assessing the significance of persistent reflux in the BK-GSV revealed that 51% of untreated varicosities in BK-GSVs showed reflux flow postoperatively. The persistent reflux group needs additional sclerotherapy for residual symptoms and residual varicosities.[3] However, EVLA of BK-GSV may also increase the morbidity rate, including nerve injury.[19]

In our study, most EPSTs were located in the third part of the leg (from the knee to the midcalf). Extended intervention may be needed from the BK-GSV up to the connection with TVs during saphenous vein stripping or laser ablation to remove potential points of recurrent development. An EPST could act as a continuous reservoir of venous reflux (Fig 3, *A*). In case of above-knee GSV ablation or short stripping to prevent cutaneous nerve damage, additional treatment including sclerotherapy, miniphlebectomy, and EPST ligation is recommended instead of extended GSV ablation (Fig 3, *B*). In this way, we can prevent development of a potential venous reservoir and nerve damage. For additional sclerotherapy or phlebectomy, treatment should be performed near escape points to prevent residual shunting (Fig 3, *B*).

A previous cartography study represented the extent of GSV reflux and location of the connection of varicose tributaries with the GSV. The study reported that recurrent VVs are manifested distally with extended GSV reflux and multiple connections of the TVs to the GSV

Table IV. Doppler ultrasound analysis of great saphenous vein (*GSV*) and tributary veins (*TVs*)

Parameters	Mean ± SD (range)
GSV diameter, near SFJ, mm	6.8 ± 1.6 (4.4-9.8)
GSV diameter, midthigh, mm	5.5 ± 1.5 (3.4-10.6)
PSV of reflux flow, cm/s	31.5 ± 16.5 (10.6-64.3)
Number of EPSTs	1.9 ± 1.0 (0-5)
TV diameter, mm	5.1 ± 1.9 (2.7-9.0)
TV/GSV diameter ratio	0.9 ± 0.3 (0.5-1.8)

EPSTs, Escape points from saphenous system to tributary vein; *PSV,* peak systolic velocity; *SD,* standard deviation; *SFJ,* saphenofemoral junction.

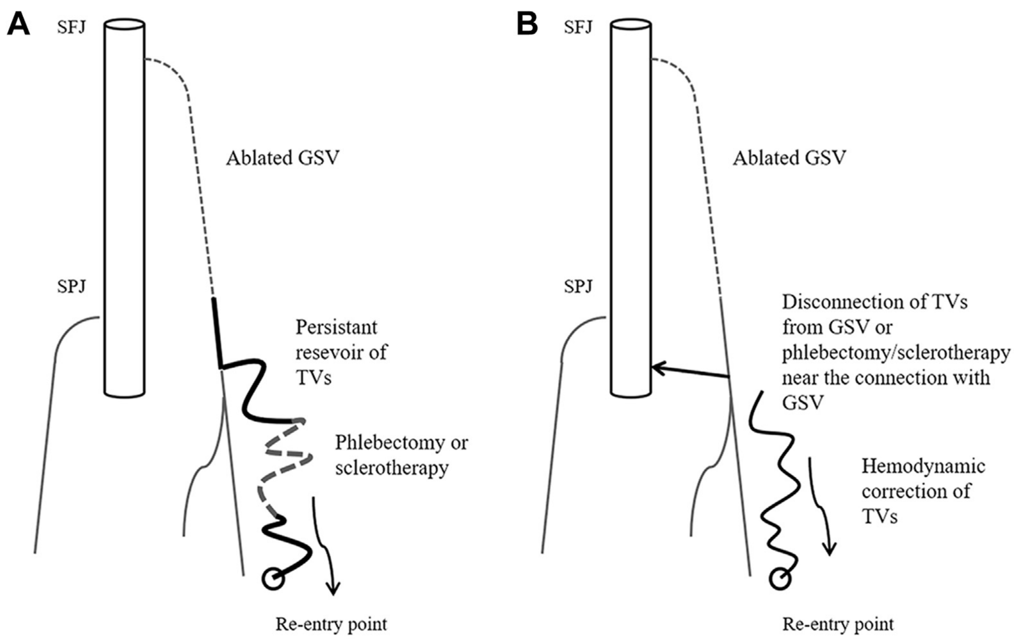

Fig 3. A, Persistent tributary veins (*TVs*) showing that reflux flow from the saphenous vein could act as a continuous reservoir of venous reflux. **B,** In above-knee great saphenous vein (*GSV*) ablation or short stripping to prevent cutaneous nerve damage, additional ligation of the TV near the saphenous vein could prevent the development of a potential venous reservoir. When additional sclerotherapy or phlebectomy is required, treatment should be performed near an escape point to prevent residual shunting. *SFJ,* Saphenofemoral junction; *SPJ,* saphenopopliteal junction.

at the calf level (46.7% vs 12.8%; $P < .05$), whereas the TV of recurrence-free VV is usually located in the thigh or upper calf. A group of patients with recurrent VVs presented with a highly extended venous reservoir and multiple connections of varicose tributaries with the GSV, especially at the calf level. However, there has been no report of whether the connection of varicose tributaries with the GSV manifested reverse flow. Therefore, it is not clear whether the connection of a TV with the GSV is the escape point from N2 to N3 compartments. However, this observation helps somewhat in selecting treatment for an EPST.[20]

In the CHIVA procedure, treatment of all sites of shunting is considered. However, other treatment methods for VVs aim to treat the SFJ or saphenopopliteal junction but do not focus on backflow from saphenous vein (N2) to superficial vein (N3). Residual reflux in the superficial vein after VV therapy may be associated with residual symptoms or recurrence because the venous reservoir may persist. Treatment of shunting between N2 and N3 could be considered to prevent recurrences. Stripping or thermal ablation may be required to treat the secondary reflux point. If stripping or thermal ablation is to be performed in the above-knee GSV, shunt division between N2 and N3 could be useful to prevent nerve damage.

If the TVs are pathologic, they are dilated and likely to be easily visible. The exact way in which to confirm an escape point is by duplex ultrasound. In this way, we could identify and make flush ligation of TVs from the saphenous trunk. Instead of flush ligation, additional sclerotherapy or phlebectomy also could be performed to remove a residual venous reservoir. During blind phlebectomy, an inadvertent long stump of a TV could remain. A long stump could be a source of recurrence or matting, like an SFJ stump (Fig 3, *A*), so removal has to be tried especially concerning escape points. Hemodynamic correction using flush ligation of escape points has been shown to reduce recurrence and complications despite the lack of prospective studies.[4] However, the hemodynamic concepts of the CHIVA procedure could be applied to laser or radiofrequency ablation procedures. In this way, we may achieve improved outcomes of treatment of VVs. Further evaluation with a prospective study should be conducted.

There are some limitations of this study. Whereas the focus of the paper is mapping of escape points, it has no follow-up and does not focus on a clinical problem directly. More patients and at least a year of follow-up are needed to demonstrate whether some of the points mentioned matter clinically. The limited number of patients studied in such a short time may lead to bias in a retrospective study. This group of patients needs to be compared with a control group of patients with the same demographics. A prospective study with longer follow-up would help overcome these limitations.

The anatomic findings do provide further support for aggressive treatment of below-knee saphenous vein incompetence and below-knee varicosities with sclerotherapy or foam therapy. This analysis of the topographic distribution of escape points may be useful in identifying potential treatment areas in patients with recurrence after treatment of incompetent GSV and VVs. This could potentially serve as a guide to design prospective evaluation of escape points in treatment of VVs. A hemodynamic approach for thermal ablation is a future research subject.

CONCLUSIONS

The most common location for EPSTs is the third part of the leg (from the knee to the midcalf), and 82.3% of all EPSTs are located below the knee. The diameter of the TV near the escape point is about 90% of the diameter of the GSV, as found in this study. According to the shunt concept, VVs are abnormal shunt formations between three different networks. Ablation of only the above-knee GSV may result in residual shunting with a persistent reservoir in TVs (Fig 3, *A*). Additional sclerotherapy or phlebectomy can be attempted to block the drainage into a superficial vein from the saphenous vein. The VV may be removed effectively by injecting sclerosant near the EPST. Miniphlebectomy can also be attempted for TVs near the EPST. Another possible option is direct ligation of EPSTs following the same approach as for SFJ ligation based on the CHIVA strategy. In the patients with BK-GSV containing reflexive TVs, these options may be able to prevent recurrence and reduce complications.

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AUTHOR CONTRIBUTIONS

Conception and design: SY
Analysis and interpretation: SY
Data collection: SY
Writing the article: SY
Critical revision of the article: SY
Final approval of the article: SY
Statistical analysis: SY
Obtained funding: SY
Overall responsibility: SY

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