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Value of delayed duplex ultrasound assessment after endothermal ablation of the great saphenous vein

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Objective: **Endothermal ablation (ETA) of the great saphenous vein (GSV) is associated with a small but definite risk of endothermal heat-induced thrombosis (EHIT) extending into the common femoral vein. Follow-up duplex ultrasound imaging to detect EHIT after ETA is considered standard of care, although the exact timing of duplex ultrasound imaging to detect EHIT after ETA remains unclear. We hypothesized that an additional duplex ultrasound assessment 1 week after ETA would not identify a significant number of patients with EHIT and would significantly increase health care costs.**

Methods: **This was a retrospective review of consecutive ETA GSV procedures from 2007 to 2014. All patients were evaluated with duplex ultrasound imaging on postprocedure day 1, and 79% of patients underwent a second ultrasound assessment 1 week postprocedure. EHIT was considered present when proximal GSV closure progressed to level ≥4, based on a six-tier classification system.**

Results: **From January 1, 2007, until December 31, 2014, 842 patients underwent GSV ETA. Patients with EHIT were more likely to have had a prior deep venous thrombosis (DVT; $P = .002$) and a larger GSV ($P = .006$). Forty-three procedures (5.1%) were classified as having EHIT requiring anticoagulation, based on a level ≥4 proximal closure level. Of the 43 patients with EHIT, 20 (47%) were found on the initial ultrasound assessment performed 24 hours postprocedure, but 19 patients (44%) with EHIT would not have been identified with a single postoperative ultrasound scan performed 24 hours after intervention. These 19 patients had a level ≤3 closure level at the duplex ultrasound scan performed 24 hours postprocedure and progressed to EHIT on the delayed duplex ultrasound scan. Lastly, thrombotic complications in four patients (9%), representing three late DVT and one DVT/pulmonary embolism presenting to another hospital, would not have been identified regardless of the postoperative surveillance strategy. Maximum GSV diameter was the only significant predictor of progression to EHIT on multivariate analysis ($P = .007$). Based on 2014 United States dollars, the two-ultrasound surveillance paradigm is associated with health care charges of $31,109 per identified delayed venous thromboembolism event.**

Conclusions: **Delayed duplex ultrasound assessment after ETA of the GSV comes with associated health care costs but does yield a significant number of patients with progression to EHIT. Better understanding of the timing, risk factors, and significance of EHIT is needed to cost-effectively care for patients after ETA for varicose veins. (J Vasc Surg 2016;■:1-6.)**

Chronic venous disease is a common condition,[1] with significant effect on quality of life.[2] The prevalence of chronic venous disease is estimated to be up to 40% in women and up to 17% in men. The prevalence of varicose veins is even greater, potentially effecting up 73% of women and 56% of men.[3] Although varicose veins are often considered a cosmetic problem, they significantly reduce quality of life in many affected individuals.[4] Current Society for Vascular Surgery (SVS) and American Venous Forum (AVF) guidelines describe endovenous thermal ablation (ETA) as a safe and effective treatment for varicose veins and recommend ETA over chemical or foam ablation for incompetent saphenous veins.[5]

With these guidelines and the heightened awareness of venous disease, it is not surprising that invasive treatments for the management of varicose veins and associated chronic venous diseases have dramatically increased during the recent era of catheter-based vascular care.[6] Indeed, >300,000 ETA procedures were perfumed in the United States in 2012.[7] This astonishing number represents an increase of 450% compared with the annual rate just a decade earlier.[8]

Along with the increased use of ETA has been a greater recognition of the potential of thrombotic complications. In response to the association between ETA and deep venous thrombosis (DVT), Jones and Kabnick[7] introduced the term "endothermal heat induced thrombosis" (EHIT) at the 2006 annual meeting of the AVF to describe the progression of thrombosis beyond the saphenofemoral junction.

Identified EHIT may be uncommon but is widely acknowledged. However, the clinical significance of EHIT and how to best manage it remain active areas of investigation.[9-12] Even with the recognized small risk of a

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postprocedure DVT or pulmonary embolism (PE), current SVS and AVF guidelines still recommend a postprocedural duplex scan within 24 to 72 hours to exclude any thrombotic complication.[5] Others perform a postprocedure duplex ultrasound scan at 5 to 7 days for patient convenience and a perceived ability to capture more thrombotic complications.[13]

The incidence of venous thromboembolism after ETA is reported to be low in clinical trials,[14] but recent evidence suggests it is several-fold greater in routine practice.[8] Specifically, the rate of DVT and PE after laser or radiofrequency ablation (RFA) is generally reported to be <1%. In contrast, O'Donnell et al[8] found the actual rates of DVT and PE were 3% and 0.55% after laser ablation and 5% and 0.58%, respectively, after RFA in real-world practice. Given these discrepant data, we questioned whether there would be value in obtaining a second delayed duplex ultrasound scan after ETA of the great saphenous vein (GSV). We hypothesized that a second postoperative duplex ultrasound scan at 1 week would not identify a significant number of patients with EHIT but would significantly increase health care costs.

METHODS

The study was approved by the Geisinger Health System Institutional Review Board. A retrospective review was performed of consecutive patients undergoing ETA of the GSV from January 1, 2007, to December 31, 2014. The Institutional Review Board did not require patient informed consent because of the retrospective nature of the study and the minimal risk posed to patients. Patients were identified from the electronic medical record using International Classification of Disease, Ninth Revision, and Current Procedural Terminology (American Medical Association, Chicago, Ill) codes. Demographics, clinical characteristics, radiologic, and operative data were obtained from the electronic medical record.

Patients were required to have been treated with graduated compression garments for a minimum of 3 months before being considered for an invasive procedure. All patients underwent preoperative duplex ultrasound imaging to confirm saphenous vein reflux >500 ms. Procedures were performed using standard techniques by board-certified vascular surgeons within one health system. Preoperative heparin or other anticoagulants were not routinely administered.

Procedures were performed in the operating room using a portable duplex ultrasound machine operated by a registered vascular technician. Percutaneous placement of the catheter in the below-knee GSV was the access site of choice. If this vein was inadequate for access, the above-knee GSV was used for access. Once venous access was obtained, the endovenous ablation catheter was advanced 2.0 to 3.0 cm caudal to the saphenofemoral junction. After the catheter position was confirmed, a liberal injection of standard tumescent solution was instilled around the saphenous vein from the catheter insertion site to the saphenofemoral junction. The vein was then treated according to the device manufacturer's recommendations.

Once the vein was treated, patients were placed in a compressive dressing. All patients (n = 842) underwent preoperative and at least one postoperative ultrasound assessment on clinic day 1, and 662 patients (79%) underwent a second delayed duplex ultrasound scan 1 week later. All ultrasound scans were reviewed by a board-certified vascular surgeon and proximal closure levels classified according to the six-tier system described by Lawrence et al.[9] EHIT was considered present when the proximal closure level progressed to level ≥4 based on the six-tier classification system.

Continuous variables are described using the mean and standard deviation or median and interquartile range (25th, 75th percentiles). Differences in continuous variables between groups were analyzed using two-sample *t*-tests if the distributions were normal or nonparametric (Wilcoxon rank-sum) tests if they were not normal. Differences in categoric variables were analyzed using χ^2 or Fisher exact tests, where appropriate. Multivariate logistic regression analysis was used to identify independent predictors of EHIT and progression to EHIT after a first ultrasound scan that showed no abnormalities. Logistic regression analysis was used to analyze the effect of CEAP class on the development of EHIT. $P < .05$ was considered significant. Statistical analysis was performed using SAS 9.4 software (SAS Institute Inc, Cary, NC).

RESULTS

This study enrolled 842 consecutive patients who underwent GSV ETA from 2007 to 2014 within one health system. All patients had at least one postprocedure ultrasound assessment, and 662 (79%) had a second ultrasound scan 1 week later. Of the 842 patients, 43 (5.1%) were classified as having EHIT as determined by a proximal closure level of ≥4 based on the six-tier classification system. Most of the patients included in this study were women, obese by body mass index (BMI) criteria, and of an older age. Further demographics, including age, gender, and BMI, did not differ between the groups with and without EHIT, with the exception of patients with EHIT were statistically more likely to have had a history of prior DVT (no EHIT: 3% vs EHIT: 9%; $P = .03$). Additional relevant demographic characteristics and comorbid medical conditions are detailed in Table I.

When comparing the preoperative medications of patients with and without EHIT, we found no difference in the preoperative use of aspirin, warfarin, or clopidogrel and no difference in the use of β-blockers, insulin, or oral hypoglycemic medications (Table I). Patients with EHIT, however, were more likely to have been prescribed preoperative statin medications (no EHIT: 19% vs EHIT: 33%; $P = .04$).

Prior venous intervention, whether open surgery or minimally invasive treatment, was rare in both groups and did not differ between them. Specific details about prior venous interventions are listed in Table II. Most

Table I. Demographics and preoperative medications of 842 consecutive patients undergoing endothermal ablations (ETAs) of the great saphenous vein (GSV) from 2007 to 2014

Variable[a]	*No EHIT (n = 799)*	*EHIT (n = 43)*	P *value*
Age, years	51.3 ± 13.7	54.3 ± 14.5	.16
BMI, kg/m^2	31.3 ± 8.0	30.8 ± 7.1	.64
Male gender	219 (27)	16 (37)	.16
Never smoker	431 (54)	22 (51)	.72
Diabetes mellitus	74 (9)	6 (14)	.29
Hypertension	241 (30)	10 (23)	.34
Coronary artery disease	47 (6)	4 (9)	.32
Dyslipidemia	253 (32)	15 (35)	.66
Obesity	156 (20)	8 (19)	.88
Prior DVT	21 (3)	4 (9)	.03
Preprocedure medications			
β-blockers	142 (18)	11 (26)	.20
Statin	155 (19)	14 (33)	.04
Aspirin	153 (19)	7 (16)	.64
Clopidogrel	13 (2)	1 (2)	.52
Warfarin	50 (6)	3 (7)	.75
Insulin	19 (2)	1 (2)	.99
Oral hypoglycemic	64 (8)	6 (14)	.52

BMI, Body mass index; *DVT,* deep venous thrombosis; *EHIT,* endothermal heat-induced thrombosis.
[a]Continuous data are shown as mean ± standard deviation and categoric data as number (%).

Table II. Surgical history, CEAP class, and maximum great saphenous vein (*GSV*) diameter of 842 consecutive patients undergoing endothermal ablations (*ETAs*) of the GSV from 2007 to 2014

Variable[a]	*No EHIT (n = 799)*	*EHIT (n = 43)*	P *value*
Surgical history			
Prior phlebectomy	36 (4)	1 (2)	.99
Prior ETA	17 (2)	2 (5)	.25
Prior GSV stripping	13 (2)	0 (0)	.99
Prior GSV ligation	12 (1)	1 (2)	.50
CEAP class			
C_1: Telangiectasia or reticular veins	5 (1)	0 (0)	.01
C_2: Varicose veins	466 (58)	19 (44)	
C_3: Edema	137 (17)	5 (12)	
C_4: Pigmentation or lipodermatosclerosis	77 (10)	8 (19)	
C_5: Healed venous ulcer	32 (4)	3 (7)	
C_6: Active venous ulcer	82 (10)	8 (19)	
Maximum GSV diameter,[b] mm	7.8 (6, 10.4)	9.3 (7, 12.3)	.006

EHIT, Endothermal heat induced thrombosis.
[a]Categoric variables are shown as number (%) and continuous variables as median (25th, 75th percentile).
[b]GSV diameter was only available in 805 patients (95%).

patients in this study were CEAP class C_2 (no EHIT: 58% vs EHIT: 44%). Logistic regression analysis showed that a higher CEAP classification was predictive of postprocedure EHIT ($P = .01$). Table II provides a complete breakdown of the CEAP classes in the study groups. Similarly, maximum GSV diameter differed (no EHIT: 7.8 mm vs 9.3 mm; $P = .006$) and was significantly larger in those patients developing postprocedure EHIT requiring anticoagulation.

Table III. Surgical variables of 842 consecutive patients undergoing endothermal ablation (ETA) of the great saphenous vein (GSV) from 2007 to 2014

Variable[a]	*No EHIT (n = 799)*	*EHIT (n = 43)*	P *value*
General anesthesia	602 (75)	16 (84)	.43
Length of surgery, minutes	71.5 ± 27.8	71.0 ± 14.8	.94
RFA	478 (59)	10 (53)	.56
Endovenous laser treatment	328 (41)	9 (47)	.56
Stab phlebectomies			
>20	252 (31)	9 (47)	.14
10 to 20	230 (29)	4 (21)	.47
<10	26 (3)	0 (0)	.99

EHIT, Endothermal heat-induced thrombosis; *RFA,* radiofrequency ablation.
[a]Continuous data are shown as mean ± standard deviation and categoric data as number (%).

Table IV. Logistic regression analysis evaluating for predictors of endothermal heat-induced thrombosis (EHIT) requiring anticoagulation in 842 consecutive patients undergoing endothermal ablations (ETAs) of the great saphenous vein (*GSV*) from 2007 to 2014

Variable	*OR*	*95% CI*	P *value*[a]
Age	1.01	0.98-1.03	.66
Male	1.45	0.74-2.84	.27
Prior DVT	3.24	0.97-10.78	.06
Max GSV diameter[b]	2.47	0.38-3.48	.02
Statin	1.27	0.54-2.92	.04

CI, Confidence interval; *DVT,* deep venous thrombosis; *OR,* odds ratio.
[a]Model includes variables from univariate analysis where $P < .20$.
[b]GSV diameter was only available in 805 patients (95%).

Table III compares the surgical variables between our two study cohorts. The type of anesthesia, use of RFA, and the length of surgery did not differ between no EHIT and EHIT patients. Correspondingly, the number of stab phlebectomies performed also did not affect the development of EHIT.

We next performed multivariate logistic regression analysis looking for predictors of EHIT (Table IV). Constructing a model with all variables having a *P* value of <.20, we arrived at results that were similar but not identical to our univariate analysis. On multivariate analysis, a history of a previous DVT failed to reach statistical significance ($P = .06$). Similar to our univariate analysis, maximum GSV diameter ($P = .02$) and statin medication use ($P = .04$) were again significantly associated with postprocedure EHIT on multivariate analysis. Although the maximum GSV diameter was expected, statin medication use was surprising, because multiple recent publications

have demonstrated an association between statin medication use and a reduction in the incidence of venous thromboembolic events in the general population.[15]

In our study of 842 consecutive GSV ETAs, we identified 43 with EHIT requiring anticoagulation, of which 20 (47%) were found on the initial ultrasound scan performed on postprocedure clinic day 1. These represent cases of EHIT identified immediately and treated with systemic anticoagulation until thrombus retraction. In contrast, 23 of EHIT cases (53%) would not have been identified with a single ultrasound scan performed 24 hours after the intervention. At the initial duplex ultrasound scan, 19 patients (44%) had a level ≤3 proximal closure level and progressed to EHIT identified on a second duplex scan 1 week later. Four patients (9%) with thrombotic complications would not have been identified regardless of the postoperative surveillance strategy. These represent three late DVTs (>2 weeks) and one DVT/PE presenting to another hospital shortly after undergoing two postprocedure ultrasound scans that showed normal (ie, level 1 closure levels) results. The three late DVTs were symptomatic with pain or edema. One was a nonocclusive common femoral DVT, and the other two were tibial vein thromboses. The overall risk for a PE in our cohort was 0.24%. The 30-day mortality was 0%.

We subsequently examined all possible variables on univariate (Table V) and multivariate analysis (Table VI) that could identify patients at risk for progression to EHIT on a delayed duplex ultrasound ($EHIT^D$) scan. Only maximum GSV diameter was significantly associated with progression to $EHIT^D$ on univariate (no $EHIT^D$: 7.8 [6, 10.4] mm vs $EHIT^D$: 11.0 [7, 12.2] mm; $P = .008$) and multivariate analysis ($P = .007$). When examining the progression of GSV proximal closure levels, we found that the rate of a level 1 or 2 closure level progressing to $EHIT^D$ requiring anticoagulation was very low, at ~1% and 3%, respectively. In contrast, level 3 closure progressed to $EHIT^D$ required anticoagulation at a rate of ~13% (Table VII). Detailed data regarding closure level progression for all patients is included as Supplementary Table I (online only). Details regarding the relationship between the maximum GSV and the development of EHIT are provided in Supplementary Table II (online only).

Lastly, we used 2014 health care charges to approximate the utilization of health care resources (Table VIII). Using a facility fee of $615 and a professional fee of $87, we estimated the charge of each unilateral postprocedural ultrasound scan was $702. When accounting for all studies and the number of significant EHIT cases found on delayed ultrasound scans, we calculated a charge of U.S. $31,109 per event identified. As calculated from current Medicare reimbursement rates, we determined the actual cost to be closer to U.S. $9523.46 per event.

Table V. Univariate analysis comparing patients without endothermal heat-induced thrombosis (*EHIT*) to those who progressed to delayed EHIT ($EHIT^D$) on delayed duplex ultrasound scan

Variable[a]	*No EHIT (n = 806)*	$EHIT^D$ *(n = 19)*	P *value*
Age, years	51.4 ± 13.8	55.6 ± 14.7	.19
BMI, kg/m^2	31.3 ± 7.9	31.9 ± 8.8	.76
Male gender	221 (27)	7 (37)	.43
Never smoker	434 (54)	11 (58)	.73
Diabetes mellitus	76 (9)	2 (11)	.70
Hypertension	243 (30)	5 (26)	.72
Coronary artery disease	48 (6)	1 (5)	.99
Dyslipidemia	257 (32)	7 (37)	.65
Obesity	158 (20)	4 (21)	.78
Prior DVT	23 (3)	1 (5)	.43
Preprocedure medications			
β-blockers	144 (18)	6 (32)	.13
Statin	158 (20)	6 (32)	.24
Aspirin	157 (20)	3 (16)	.99
Clopidogrel	13 (2)	0 (0)	.99
Warfarin	50 (6)	2 (11)	.34
Insulin	20 (3)	0 (0)	.99
Oral hypoglycemic	66 (8)	2 (11)	.67
Surgical history			
Prior phlebectomy	36 (5)	0 (0)	.99
Prior ETA	17 (2)	0 (0)	.99
Prior GSV stripping	13 (2)	0 (0)	.99
Prior GSV ligation	12 (2)	0 (0)	.99
Maximum GSV diameter,[b] mm	7.8 (6, 10.4)	11.0 (7, 12.2)	.008
Surgical variables			
General anesthesia	602 (75)	16 (84)	.43
Length of surgery, minutes	71.5 ± 27.8	71.0 ± 14.8	.94
RFA	478 (59)	9 (52)	.56
Endovenous laser treatment	328 (41)	9 (47)	.56
Stab phlebectomies			
>20	252 (31)	9 (47)	.14
10 to 20	230 (29)	4 (21)	.47
<10	26 (3)	0 (0)	.99

BMI, Body mass index; *DVT*, deep venous thrombosis; *ETA*, endothermal ablation; *GSV*, great saphenous vein; *RFA*, radiofrequency ablation.
[a]Continuous data are shown as mean ± standard deviation or median (25th, 75th percentile) and categoric data as number (%).
[b]GSV diameter was only available in 805 patients (95%).

DISCUSSION

Despite the small risk of a postprocedure DVT or PE, current SVS and AVF guidelines recommend postprocedural duplex scan with 24 to 72 hours to exclude any thrombotic complication.[5] The purpose of our study was to analyze the value and effectiveness of a second duplex ultrasound scan 1 week after ETA of the GSV, in addition to a scan performed 24 hours postprocedure. Before starting this investigation, we suspected that the use of a second delayed ultrasound scan would only slightly increase the detection of post-ETA EHIT. We were, however, surprised at the significant yield of this additional test. In our study of 842 consecutive ETA procedures, we identified 43 cases (5.1%) of EHIT requiring anticoagulation. Of these 43 cases, only 20 (47%) were found on the initial ultrasound scan performed 24 hours postprocedure, and 19 (44%) were identified on a delayed second duplex ultrasound scan.

Table VI. Logistic regression analysis evaluating for predictors of progression to endothermal heat-induced thrombosis (EHIT)

Variable	*OR*	*95% CI*	P *value*[a]
Age	1.02	0.98-1.06	.39
β-blocker	1.52	0.48-4.83	.48
Max GSV diameter[b]	4.18	1.47-11.84	.007
>20 stab phlebectomies	1.83	0.70-4.75	.22

CI, Confidence interval; *GSV,* great saphenous vein; *OR,* odds ratio.
[a]Model includes variables from univariate analysis where $P < .20$.
[b]GSV diameter was only available in 805 patients (95%).

Table VII. Risk of progression to endothermal heat-induced thrombosis (EHIT)

Proximal closure level	*Level ≥4 closure, No.*	*Closures at a given level, No.*	*Risk of progression, %*
Level 1	7	604	1.16
Level 2	6	174	3.45
Level 3	6	47	12.77

We feel it is important to highlight that one-third of all progression to EHIT cases were level 3 closures on the initial ultrasound scan that underwent observation alone. In the subgroup of patients with a level 3 closure, two were started on low-molecular-weight heparin empirically (and did not progress to level ≥4 proximal closure level), and one resumed chronic warfarin therapy. In the remainder of patients with a level 3 closure, observation was associated with an unacceptably high rate of progression to significant EHIT. If these patients had undergone treatment with systemic anticoagulation, the yield of the second delayed duplex scan in our study would have been significantly reduced at ~30% and would also have reduced the percentage of patients with a level ≥4 closure to ~4%.

After considering these findings, we believe it is reasonable, and possibly more cost effective, to omit a second ultrasound scan in patients who achieve a level 1 or 2 proximal closure at 24 hours postprocedure. This approach in our study population, albeit with a small risk of progression to EHIT (1% to 3%), would result in 590 fewer ultrasound scans and a charge reduction of $417,478. Furthermore, we believe our results clearly demonstrate that a second postprocedural ultrasound scan is highly recommended for level 3 closures. Our recommendation is further supported by a recent study from Sufian et al.[16] They found untreated EHIT class 1, which is analogous to Lawrence closure level 3, worsened at a rate of 11%, albeit this was at 1- month follow-up in a mixed population of great and small saphenous vein ablations.

We believe our results compare favorably with the existing literature, but several variances require further discussion. Lawrence et al[9] used outcomes in a cohort of 500 consecutive patients to construct a classification system to describe the level of proximal GSV closure in patients undergoing RFA. We routinely use this classification in our clinical practice and find it extremely valuable. In that investigation of 500 patients, Lawrence et al[9] reported 21 level 3 closures managed with observation (ie, weekly ultrasound scans until thrombus retracts) or low-molecular-weight heparin and reported no thrombus extension into the common femoral vein with either approach. In contrast, we found progression of thrombus into the common femoral vein in ~13% of our patients with level 3 closures undergoing observation. Furthermore, Lawrence et al[9] reported only 2.6% of patients developed a level ≥4 closure, a rate significantly lower than our own.

Table VIII. Health care charges associated the two-ultrasound scan paradigm after endothermal ablation (ETA) of the great saphenous vein (GSV) from 2007 to 2014 (based on 2014 fees)

Facility fee	*Professional fee*	*Total fee*	*×842 procedures*	*Charge per EHIT event*
$615.00	$87.00	$702.00	$591,084.00	$31,109.68

EHIT, Endothermal heat-induced thrombosis.

The reason for this difference is not entirely clear, but several possibilities are plausible. It is conceivable that that our patient populations are different. Our patients had more advanced venous disease, with 58% at CEAP C_2, compared with 89% at CEAP C_2 in the Lawrence et al[9] cohort. Our study, along with that of others,[11] found a higher CEAP C class was predictive of thrombotic complications after GSV ETA. Specifically, Rhee et al[11] found a 4% rate of EHIT in 519 cases of ETA, with CEAP class predictive of postprocedural EHIT ($P = .003$), along with male gender ($P = .0003$) and a history of venous thrombosis ($P = .04$). It is also possible that we had a population with a greater rate of obesity (mean BMI >30 kg/m^2), a well-defined risk factor for venous thromboembolism.[17] The combination of these two risk factors could conceivably have contributed to the increased incidence of thrombus progression in our cohort with level 3 proximal closures. It is also possible that our increased use of general anesthesia may have contributed to the increase; however, we could not demonstrate general anesthesia as a causative factor. Opting for alternative anesthesia modalities, as opposed to general anesthesia, may provide potential protection against thrombotic complications.[18]

Despite these differences, our study is analogous to the investigation by Lawrence et al[9] in many ways. We too found prior DVT and large GSV diameter were risk factors for EHIT requiring anticoagulation. Corroborating these findings are other investigations demonstrating that a large GSV diameter[12] and prior DVT[19] are significant predictors of EHIT. We acknowledge that our obese patient population, more advanced venous disease, use of general anesthesia, and high prevalence of concomitant phlebectomy make our results less generalizable to the practice of many venous interventionalists. Furthermore, the role of

evolving minimally invasive treatment options, such as duplex ultrasound-guided foam sclerotherapy and endovenous glue application, in the care of patients with chronic venous disease is yet to be determined.

Although our findings add to the care of patients with chronic venous disease, we acknowledge that our study has several limitations. First, this was a single-center nonrandomized retrospective study. We accept that even though careful manual record and ultrasound scan review was performed to gather the data for this study, important clinical events may have been missed due to the nature of the data collection.

Second, the study consisted of patients with different disease severity undergoing a variety of procedures by multiple vascular surgeons. This combined with the lack of standardized postoperative management strategy, in relation to the management of advanced closure levels, limits the ability to make more definitive recommendations based on our findings.

Third, the small number of EHIT events and the even smaller number of patients in certain closure subgroups may have introduced a type II error, particularly in regards to the identification of risk factors for EHIT or the progression to EHIT.

CONCLUSIONS

The incidence of EHIT after GSV ETA is greater than many providers assume. A significant number of EHIT cases involving the common femoral vein are not identified with a single day 1 postprocedural duplex examination. Delayed duplex ultrasound scanning after GSV ETA comes with associated health care costs but does yield a significant number of patients with progression to EHIT. Owing to a significant rate of propagation, patients with thrombus flush with the common femoral vein (level 3 closure) after GSV ETA should undergo follow-up ultrasound scans if the patient is not being treated with systemic anticoagulation. A better understanding of the timing, all risk factors, and the significance of EHIT is needed to more cost-effectively care for patients after invasive treatment for varicose veins.

AUTHOR CONTRIBUTIONS

Conception and design: ER, JE, RG, DF
Analysis and interpretation: ER, JE, RG, MC, JD
Data collection: ER, JE, RG, MC, SK
Writing the article: ER, JE, RG
Critical revision of the article: ER, JE, RG, MC, JD, SK, DF
Final approval of the article: ER, JE, RG, MC, JD, SK, DF
Statistical analysis: ER, JD
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Overall responsibility: ER

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Supplementary Table I (online only). Risk of any closure level progression after endothermal ablation (ETA) of the great saphenous vein (GSV)

Closure level from 1st to 2nd duplex ultrasound	*Patients, No.*	*Risk of progression, %*
Level 1 to 2	44	7.3
Level 1 to 3	18	3.0
Level 1 to 4	7	1.2
Level 1 to 5	0	0
Level 2 to 3	9	5.2
Level 2 to 4	6	3.4
Level 2 to 5	0	0
Level 3 to 4	2	4.3
Level 3 to 5	4	8.5

Supplementary Table II (online only). Incidence of level 4 or 5 closure by great saphenous vein (*GSV*) maximum diameter

		4 or 5 closures on first ultrasound		
GSV diameter, mm	*Total, No.*	*No.*	*%*	*95% CI*[a]
3.0-5.0	102	1	0.98	0.01-5.88
5.1-8.0	327	6	1.83	0.75-4.04
8.1-10	158	4	2.53	0.77-6.55
<10	593	11	1.85	1.00
		4 or 5 closures on second ultrasound		
3.0-5.0	75	0	0.00	0.00-5.84
5.1-8.0	246	7	2.85	1.27-5.87
8.1-10	125	4	3.20	0.98-8.21
<10	452	11	2.43	1.31-4.36

CI, Confidence interval.
[a]Modified Wald method used to calculate 95% CI.