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Article

Availability of the Great Saphenous Veins as Conduits for Arterial Bypass Surgery in Patients with Varicose Veins

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Abstract: Background: The great saphenous vein (GSV) has long been recognized as a best conduit for vascular bypass procedures. Concomitant varicose veins disease may be a reason for GSV unavailability either due to dilatation and tortuosity of the vein or due to its destruction during invasive venous treatment. **Aim** - to assess the rate of varicose vein patients with concomitant lower extremity arterial disease (LEAD) who have previously lost their GSV due to venous ablation. **Material and methods:** 285 patients (76 F, 209 M) with LEAD were consecutively enrolled. Demographic data and medical history were taken. Physical examination and duplex ultrasound were performed. We registered presence of varicose veins (VVs), type of previous invasive procedure and availability of saphenous veins as possible grafts. **Results:** Mean age of screened LEAD patients was 70.5±9.1. 62 (21.75%) patients had varicose veins or were operated on before due to varicose veins. 42 patients with varicose veins had C2 disease, 10 had C3, nine had C4 and one had C6 according to CEAP classification. Duplex ultrasound examination of the veins of the lower extremities was performed on 111 patients (222 lower extremities). The total number of lower extremities without ipsilateral GSV was 76 (34.2%) due to varicosity, small size, previous ablation or postthrombotic intraluminal changes. 53 limbs in 32 patients had VVs. Despite the presence of varicose tributaries, the GSV was suitable for bypass in 9 lower extremities. GSV was not available as a conduit in 34 (20.1%) ipsilateral lower extremities in the LEAD group and in 42 (79.3%) ipsilateral lower extremities in the LEAD with VVs group (p= 0.0001). Varicose vein disease was associated with a higher frequency of the GSV unavailability odds ratio 18.8 (95% confidence interval 8.35 – 42.35). On the 11 ipsilateral limbs (5%) GSV was unavailable due to previous venous interventions. **Conclusions:** Almost 20% of patients may have both LEAD and VVs. Among those with VVs, most have the ipsilateral GSV unavailable as a potential conduit. Additionally, one fifth of limbs with VVs had GSVs destroyed previously due to saphenous ablative procedures.

Keywords: varicose veins; vein saving surgery; hemodynamic correction; atherosclerosis; peripheral artery disease; arterial disease

Introduction

Significant progress has been made in the treatment of lower extremity arterial disease (LEAD). An active approach for managing critical limb ischemia includes surgical restoration of the lower extremities blood supply [1]. The development of new generations of vascular prostheses and improvements in bypass and endarterectomy techniques have led to a reduction in mortality, amputation, and impaired quality of life. However, the short-term and long-term results of surgical correction of arterial blood flow are mainly determined by the state of the arterial outflow of the calf and foot [2]. The patency of the bypass graft depends on various factors. The most important are the

type of operation, the material from which the prosthesis is made, the length of the conduit, and the patient's coagulation conditions [3,4]. It is generally accepted that blood flow contributes the most to conduit failure [1,2].

Results of reconstructive surgery below the inguinal ligament depends on used material. It is crucially important for below-knee bypass. The current guidelines of the European Society for Vascular Surgery outline that availability and quality of an autologous vein conduit are key for successful bypass surgery [2]. The guidelines of the European Society of Cardiology (ESC) on the diagnostics and treatment of peripheral artery disease (PAD) recommend the autologous saphenous vein as the conduit of choice for femoropopliteal bypass (Grade IA). Moreover, it is recommended to prefer the great saphenous vein (GSV) for infra-popliteal arteries bypass (Grade IA) [1]. This recommendation is based not only on the fact that the autologous vein shows better patency in the infra-inguinal position than prostheses but also because it is more resistant to postoperative infectious complications [3]. An autologous vein graft from the GSV of the same limb shows the best patency and preservation of the limb compared to other autologous veins [3]. However, there are several patients with critical limb ischemia who need infra-inguinal bypass but do not have a GSV on the same limb. This is usually due to previous coronary artery bypass grafting (CABG), femoropopliteal proximal or distal bypasses that have already been performed [5]. The vein may have a small caliber or being damaged as a result of superficial thrombophlebitis. Overall, 20-45% of LEAD patients may have no GSV for bypass [6-8].

One of the reasons of GSV unavailability is its previous ablation in patients with concomitant varicose veins [6-8]. In the last two decades, there has been a significant increase in the number of endovenous ablations of saphenous trunks in patients with varicose veins and a growing number of young and middle-aged individuals who have undergone ablative venous procedures may face problems with venous conduits when they become elderly [9].

Aim - to assess the rate of varicose veins patients with concomitant LEAD who have previously lost their GSV due to venous ablation before.

Material and Methods

Study Design

This was a single-center study conducted on symptomatic patients with LEAD referred to vascular surgery department for consultation. Patients were consecutively enrolled from December 2023 to May 2024.

Inclusion and Exclusion Criteria

All the patients of both sex having LEAD affecting one or both legs were included. Only those who refused to sign an *informed consent* were excluded.

Data Collection

Demographic data and medical history were collected. The Rutherford classification was used to describe patient arterial status. Physical examination and duplex ultrasound were performed to assess the presence of varicose veins, previous invasive procedures, and availability of saphenous trunks as potential grafts. Duplex ultrasound was performed in a standing position to access deep veins and GSV. We evaluated the competence of the GSV terminal valve, the presence of reflux in the GSV (≥ 0.5 sec) and deep vein reflux (≥ 1 sec). Considering that the GSV is the conduit of choice for bypass the study focused on the GSV only. Patients with varicose veins were classified according to the CEAP classification and assessed for a history of superficial thrombophlebitis.

In all the recruited patients GSVs were thoroughly assessed in details during duplex ultrasound investigation. We aimed to assess if GSV was possible to use as a conduit. We found no criteria defining the suitability of a vein as a bypass graft in previously published papers. We considered GSV as available if the vein diameter was more than 4 mm, no varicosity transformation and/or post-thrombotic changes due to superficial thrombophlebitis were registered. The absence of GSV due to

phlebectomy, endovenous thermal or non-thermal ablation, as well as previous CABG or femoropopliteal bypass, was registered.

Approval

The study protocol was approved by the Ethical Committee of Pirogov Russian National Research Medical University (No. 192, 21.12.2019) and registered on clinicaltrials.gov as NCT06332833.

Data Analysis

Statistical analysis was performed using SPSS 23 software. Descriptive data are presented as n (%) for categorical variables and as mean \pm SD for continuous variables. For group comparisons of all other metric variables, the Mann–Whitney U test was used for independent groups. Categorical variables were compared by Pearson's chi-squared test or Fisher exact test. Values of $p < 0.05$ were considered significant for all tests.

Results

285 patients with LEAD were assessed for eligibility. Of these, 209 (73.3%) were male and 76 (26.7%) were female, with a mean age of 70.5 ± 9.1 years. There were no patients with previous deep vein thrombosis. Distribution of LEAD severity according to Rutherford classification is shown in Table 1.

Table 1. Stage of LEAD according to Rutherford classification.

Category	All patients, n=285	Male, n=209	Female, n=76
1	66 (23.2%)	47 (22.5%)	19 (25%)
2	84 (29.5%)	64 (30.6%)	20 (26.3%)
3	105 (36.8%)	78 (37.3%)	27 (35.5%)
4	16 (5.5%)	11 (5.3%)	5 (6.6%)
5	14 (5%)	9 (4.3%)	5 (6.6%)

Among the patients assessed, 62 (21.75%), including 44 males and 18 females, had varicose veins (13%) or had undergone previous varicose veins related procedures (8,75%). Mean age of this cohort was 63.8 ± 10.5 . 42 patients had C2 disease, 10 had C3, nine had C4 and one had C6 according to CEAP classification.

Duplex ultrasound of the veins of the lower extremities was performed on 111 patients (222 lower extremities). Of them there were 32 patients with VVs presented on 53 limbs. Some characteristics of patients with and without VVs who had undergone duplex ultrasound are presented in Table 2.

Table 2. Demographics and clinical characteristics of both groups' patients.

	Group		p
	LEAD only (n = 79)	LEAD with VV (n = 32)	
Age	$69 \pm 10,9$	$72.3 \pm 10,1$	0.825
Male	16 (20%)	12 (37.5%)	0.058
Female	63 (80%)	20 (62.5%)	
Diabetes	22 (27.8%)	9 (28.1%)	0.976
Smoking	58 (73.4%)	18 (56.3%)	0.078
Diabetes plus smoking	10 (12.6%)	3 (9.3%)	0.062

The total number of lower limbs lacking an ipsilateral GSV was 76 (34.2%). The absence of GSV as a conduit was significantly higher in the LEAD with varicose veins group (Table 3).

Table 3. Unavailability of GSV on the ipsilateral lower extremity (limbs, n=222).

	Group		P
	LEAD (n = 171)	LEAD with VVs (n = 51)	
GSV unavailable	34 (19.9%)	42 (82.6%)	0.0001
Small size (less than 4 mm)	24 (14%)	1 (2%)	0.016
Removed for bypass before	10 (5.9%)	-	-
Dilation and/or varicosity	-	24 (47%)	-
Previous ablation of GSV	-	11 (21.6%)	-
Postthrombotic intraluminal changes	-	6 (11.8%)	-

Varicose vein disease was associated with a higher frequency of the GSV unavailability odds ratio 18.8 (95% confidence interval 8.35 – 42.35). Despite the presence of varicose tributaries, the GSV trunk was suitable for bypass in 9 of lower extremities with VVs.

Discussion

We conducted a single-center cross-sectional study on consecutive symptomatic LEAD patients. The primary objective of our study was to evaluate the impact of venous interventions in patients with varicose veins on the availability of the GSV as a potential conduit for future bypass surgery.

Almost a quarter of individuals with LEAD have concomitant varicose veins. We found that the ipsilateral GSV was overall unavailable in a third of LEAD patients. Presence of VVs disease leads to frequent ipsilateral GSV unavailability. On limbs with VVs ipsilateral GSV was unavailable in 82.6% cases compared with 20% of limbs without VVs.

The most often GSV was dilated and/or tortuous which was observed in a half of lower extremities with VVs. On 21.6% limbs ipsilateral GSV was unavailable due to previous venous interventions. Two patients lost their GSVs after venous interventions on both legs. One of them was a 65-year-old male with LEAD, who had occlusion of the superficial femoral artery in both legs, classified as Rutherford stage 3. The patient had previous endovenous laser ablation of both GSVs 10 years ago. Additionally, he underwent coronary artery bypass grafting (CABG) procedure using the radial artery 5 years ago due to the lack of suitable venous conduits. In this clinical scenario, the absence of a venous conduit for bypass surgery in the lower extremities poses a significant threat of limb loss.

Among the cohort of patients with LEAD and concomitant varicose disease, only three patients currently presented with critical ischemia, necessitating revascularization procedures. Two patients underwent a percutaneous transluminal angioplasty of the superficial femoral artery, while one patient received a bypass grafting procedure using the contralateral GSV. Most patients in our study do not currently require bypass procedures; however, they may become candidates for such interventions in the future. Nonetheless, some of these patients may lose their GSV due to the endovenous treatment of varicose disease during this period.

We found only two papers with similar data presented. Taylor LM et al. reported GSV unavailability in 43% of PAD patients. The GSV was absent because of previous vein stripping or previous utilization as a bypass conduit in 23% limbs and in 20% due to small size (diameter less than 4 mm) [7]. Chew D.K.W. et al. found no GSV suitable for bypass in about 20. with no exact information of what were the reasons of vein unavailability [10]. A similar rate was found in our study.

With the growing life expectancy, the number of patients in need for bypass surgery will increase. Almost a quarter of the population in developed countries are older than 65 years: 36% in Monaco, 30% in Japan, 24% in Italy, 23% in Finland, 22 in Germany, etc [11]. Due to that, the number of patients with LEAD increases. Annually, the total number of interventions due to LEAD in USA only increased by 15% between 2001 and 2007 (106,018 vs. 121,596, $p < 0.001$) [12,13].

On the other hand, in the last two decades, the number of venous interventions performed on VVs patients have severely increased. The first to pay attention on this was P. Lawrence [14]. His report showed that from 1996 to 2014, the number of venous ablation procedures increased by 4529% [15]. This information was so horrifying that Russell Samson, editor of *Vascular Specialist* in irony proposed a new society titled "Save Our Saphenous" [16].

Crawford J.M. et al. extracted data on practice trends in endovenous ablation from the Medicare Data Utilization and Payment Database [9]. It has been shown that there is a steady increase in the number of patients undergoing ablation from 2012 to 2015. The number of procedures grew from 132200 to 170033, and the number of patients from 74333 to 91441. Procedures per patient averaged 1.8 in the aggregate dataset. The total number of providers performing more than two ablations per patient on average almost doubled from 301 to 511. Moreover, the number of ablations per patient was higher if the ablation was performed by a physician with no vascular training. P. Lawrence suggested that this situation could be due to the fact that some physicians may not be aware of the published literature and practice guidelines, or maybe not be proficient in duplex ultrasound imaging and reflux valuation [17].

According to the Cochrane database of systematic reviews on interventions for GSV incompetence, the mean age of people who underwent venous intervention was about 50 years [18]. In our research, mean age of patients who had come to our clinic with LEAD was $70,5 \pm 9,1$. This means that people who underwent venous intervention in 2012-2016 are not yet at the age of LEAD manifestation and they may face problems with venous conduits in the next decade when they become elderly. Furthermore, the problem with the GSV destruction may increase rapidly due to opinion of some specialists that patients who have symptomatic C1 patients with refluxing saphenous veins without visible varicose veins could be candidates for an ablation procedure [19].

Summing up, vascular surgeons will see much more patients with destructed GSV in the coming years. That is why it may be worth to take a closer look at hemodynamic approaches such as CHIVA and ASVAL. Claude Franceschi was the first to suggest the possible need to preserve the main trunks of the saphenous veins and proposed the ambulatory conservative hemodynamic correction of venous insufficiency (CHIVA) method [20]. Subsequently, followers of his technique P.Zamboni, S. Giancesini, E.Mendoza supported this method and the possibility of using the preserved saphenous veins as future bypass [21]. Hemodynamic approach means eliminating of the escape point, saving re-entry points, and preserving saphenous trunks [22]. Most studies show that this technique could not only help to preserve the trunk of the saphenous veins but also decrease the diameter of the GSV to normal calibers [23–26].

On the other hand, hemodynamic correction doesn't mean that GSV is saved for long time period. In the first year after hot-CHIVA, the recurrence of varicose veins was 4.9%, which is similar to standard RFA [26]. The recurrence after ASVAL procedure after 1 year was 10,8%, after 2 years - 22,7%, after 3 years - 33.1%, after 4 years - 46.5%, and after 5 years - 66.3 [18,27]. This can make hemodynamic approach not that attractive. But, the fact that 21% of limbs with VVs had GSVs destructed before makes the idea of CHIVA proponents at least worth to discuss.

Limitations. There are several limitations to our study. These include the relatively small sample size and the inability to confirm the availability of the GSV in all patients due to the lack of duplex ultrasound during consultations. Additionally, this research was conducted at a single hospital only. We also included only patients who actively seek medical help. Approaches to VVs ablation are also different in other countries so they may have another magnitude of the problem.

Conclusions

Both LEAD and VVs diseases can be found in about one fifth of patients. Among those who have VVs the majority have ipsilateral GSV unavailable as a possible conduit. 20% of limbs with VVs veins had GSVs totally destructed before due to saphenous ablative procedures.

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Consent to participate: All participants have agreed to be included in this clinical study.

Author's contributions: Conceptualization, Veronika Golovina and Igor Zolotukhin; Data curation, Veronika Golovina and Vladislav Panfilov; Formal analysis, Veronika Golovina, Vladislav Panfilov, Evgenii Seliverstov, Darina Erechkanova and Igor Zolotukhin; Investigation, Veronika Golovina; Methodology, Veronika Golovina and Igor Zolotukhin; Project administration, Veronika Golovina and Igor Zolotukhin; Resources, Veronika Golovina and Vladislav Panfilov; Software, Veronika Golovina and Vladislav Panfilov; Supervision, Veronika Golovina, Evgenii Seliverstov and Igor Zolotukhin; Validation, Veronika Golovina, Vladislav Panfilov, Darina Erechkanova and Igor Zolotukhin; Visualization, Veronika Golovina; Writing – original draft, Veronika Golovina; Writing – review & editing, Veronika Golovina and Igor Zolotukhin.

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