Chemical and mechanochemical catheter-directed sclerotherapy in varicose vein ablation

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Background
Varicose vein, as well as the accompanied venous insufficiency, is a frequent disorder, affecting ~30% of the Western population. Chronic venous insufficiency has a major effect on patients' health-related quality of life, similar to different chronic disorders, including diabetes mellitus as well as cardiovascular diseases.
Aim
The aim of this study was to assess and compare the applicability, technique, and results of catheter-directed foam sclerotherapy in the management of varicose vein with and without mechanical injury to the vein wall.
Patients and methods
The study was conducted on 104 patients with primary varicose vein between November 2017 to October 2019. All patients were admitted to Vascular Surgery Department in Mansoura University hospitals. They were divided into two groups: group A (chemical ablation) included 79 patients, and group B (mechanochemical ablation) included 25 patients.
Technique
In chemical ablation group, catheter-directed foam sclerotherapy of great saphenous vein was done using Aethoxysklerol 3% by ureteric catheter. In mechanochemical ablation group, catheter-directed foam sclerotherapy of the great saphenous vein was done using Aethoxysklerol 3% through Flebogrif catheter.
This was a nonrandomized prospective comparative study.
Results
Complete occlusion was reported at 3 months for all cases of group A (100%) and 19 (76%) of cases in group B, and after 6-month follow-up, occlusion occurred in 43 (54.43%) cases among group A and 22 (88%) of cases among group B and long-segment recanalization in 36 (45.56%) of cases among group A and three (12%) of cases among group B.
Complications developed in 22 cases in group A and five cases in group B. In group A, 20 cases developed painful thrombophlebitis, one case reported DVT, and only one case reported respiratory distress. However, in group B, four cases developed painful thrombophlebitis and one case reported hyperpigmentation along the course of the vein.
Patients in group B were more satisfied than group A patients, with significant difference, and also group B patients has less pain sensation than group A patients, with significant difference.
Conclusions
Catheter-directed foam sclerotherapy is accepted in the treatment of primary varicose vein with short-term and mid-term success in varicose vein ablation and has a low incidence of complications. Mechanochemical occlusion is preferred than catheter-directed foam sclerotherapy, with better results and fewer complications.

Keywords:
catheter directed foam sclerotherapy (CDFS), chemical ablation, endovenous sclerotherapy, mechanochemical ablation, varicose vein, vein closure

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Introduction

Varicose vein, as well as the associated venous insufficiency, is a common disorder, affecting 20–40% of the Western population. Chronic venous insufficiency has a high effect on patients' health-

related quality of life, comparable with other chronic diseases such as diabetes and cardiovascular disease [1]. Incompetence of the great saphenous vein (GSV) has traditionally been treated with saphenofemoral high ligation and stripping of the thigh GSV. However, the need for an operating theater, complications, unsatisfactory recurrence rate, as well as poor cosmetic outcome after surgery have led to the development of minimally invasive techniques during the last decade [2].

These modern endovascular techniques challenge surgery as the gold standard for treatment of venous insufficiency. Many studies have described ultrasound-guided foam sclerotherapy (UGFS), which is attractive owing to its safety profile, simplicity, and cost-effectiveness. The heterogeneity between the studies is substantial, a variation of UGFS technique is used, and many report results after repeated UGFS, which limits comparisons [3].

Sclerotherapy refers to the introduction of a drug into the lumen of a vein with the intended consequence of endoluminal venous fibrosis and subsequent vein closure. Clinically, vein closure is desired to mitigate the effects of venous hypertension caused by retrograde venous flow. The mechanism of action of sclerosing solutions is directed toward the complete destruction of endothelial cells lining the venous lumen, exposure of subendothelial collagen fibers, and formation of a fibrous cord [4].

Foam sclerotherapy is cheap, does not require anesthesia, is effective, can be repeated, and has an acceptable safety profile. The treatment rationale is that sclerosant agents damage the endothelium irreversibly by disrupting cell membranes, resulting in sustained vasospasm and vessel obliteration [5].

The direct instillation of sclerosant agents as 'microfoam' with carbon dioxide or air to leads to an attractive treatment for axial reflux in the great or small saphenous vein (GSV and SSV). Many reports have documented the potential advantages of this technique for treating incompetent axial veins. Publications focused on foam preparation techniques and the necessary amount of sclerosant agent [6].

The Tessari method, as an easy, inexpensive, and repeatable extemporary method to create durable and dense sclerosant foam, contributed to this diffusion. UGFS has significantly increased in popularity and acceptance in the international vascular community, although a lack of standardization in the process of sclerosing foam (SF) formation and SF injection has been highlighted by different authors, and several variables objectively interfere with SF formation/injection [7].

In this study, we introduced the sclerosing material through the catheter to stimulate maximum vein spasm minimizing the drug dose and to be sure that all vein segments has direct contact with the drug with maximum opportunity to occlude the vein and abolishing the reflux. Moreover, in group B, we used a special catheter with hooks to injure the vein wall to occlude the vein.

Patients and methods

Between November 2017 and October 2019, 104 patients were treated for primary varicose veins with proven GSV incompetence. The age range among group A was 18–64 years, and 49.36% of cases were females, whereas among group B, age range was 21–61), and 92% of cases were females. After ethical committee approval and taking consent, those with vein diameter of GSV not exceeding 12 mm on supine position measured 2 cm distal to sapheno femoral junction (SFJ) were included. The patients were divided into two groups: 'group A,' chemical ablation, and 'group B,' mechanochemical ablation. Clinical and demographic data and vein diameter are shown in Tables 1–4.

Both techniques were offered to the patients, and they had the right to choose between them, keeping in mind that those choosing mechanochemical ablation had to pay the price of the catheter.

Table 1 Demographic data in group A and group B

Demographic data	Group A (*N*=79)	Group B (*N*=25)
Age (years)		
Mean±SD	34.88±9.46	34.72±10.07
Range	18–64	21–61
Sex [*n* (%)]		
Male	40 (50.63)	2 (8)
Female	39 (49.36)	23 (92)

Table 2 CEAP grading between group A and group B

Variables	Group A (*N*=79) [*n* (%)]	Group B (*N*=25) [*n* (%)]	*P* value
C2	29 (36.7)	11 (44)	0.513
C3	50 (63.29)	14 (56)	0.513

CEAP, clinical, etiological, anatomical, pathological.

We made a questionnaire about pain score 2 weeks postoperatively (first follow-up visit) among the included patients using numerical rating scale (NRS) score, which was classified into mild, moderate, and severe.

There is no individual main source document for the 0-to-10 NRS of pain intensity; however, Dworkin *et al.* (2005) [8] may be cited as a source that suggested the NRS over other pain intensity measures, and Jensen (2010) [9] concludes a proof which reinforces the consistency of 0-to-10 NRSs for evaluating pain intensities. The number that the respondent chooses is that respondent's NRS score. Pain intensities are categorized according the NRS score.

Minimal pain intensity is obvious but has slight effects on day-to-day functioning. On the contrary, modest pain has a role to particular regions of functioning, including socializing, sleep, and mood, but does not induce marked interference via a wide spectrum of actions. Severe pain becomes a central form of the patient's life, with subsequent production of a considerable interference in a broad spectrum of activities.

The scores were graded as follows:

No pain: 0; mild: 1–4; moderate: 5-6; and severe: 7–10.

Patients' satisfaction is a measure of health care, and hospitals globally use it to enhance the quality of health care (Cleary and McNeil, 1988) [10]. In the past decades, it was used to assess the quality of medical services by assessing the aim of patients' outcomes of physical conditions. Nowadays, authors have started to pay close attention to patients' acceptance as a yardstick for evaluating the efficiency and quality of medical care. Although the quality of medical services can be assessed by several perspectives, including doctors, patients, or insurers, patients must be considered as the most essential estimator of care quality. Patients' opinions and satisfaction status might affect their future behaviors related to the therapeutic outcomes (Vuori, 1987) [11].

We made a questionnaire for patients' satisfaction 6 months after the procedure and classified them based on it to very satisfied, satisfied, and nonsatisfied.

Table 3 Veins and vein diameter between group A and group B

Variables	Group A (*N*=79)	Group B (*N*=25)	*P* value
Vein			
GSV	79	25	1
Diameter			
Mean	9.07±1.01	8.57±0.68	0.023

GSV, great saphenous vein.

Table 4 Mean diameter of succeeded and failed cases among group A and group B

Variables	Group A (*N*=79)	Group B (*N*=25)
Mean diameter of succeeded cases	8.14	7.90
Mean diameter of failed cases	10.05	9.45

Technique

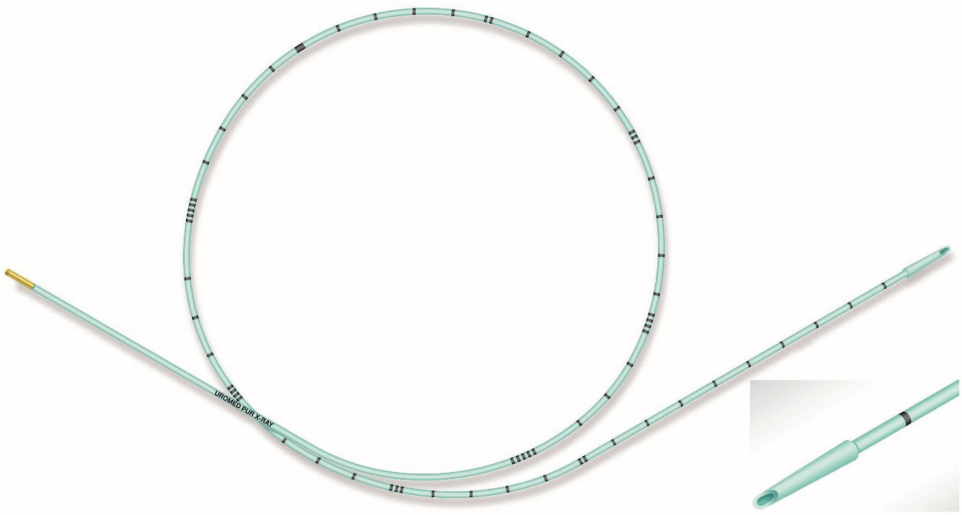
Thorough history and physical examination were done for all the patients included in the study using the color duplex ultrasound with high-resolution transducer (10 MHz). Duplex ultrasound was carried out for all patients to confirm the diagnosis and to rule out deep venous thrombosis as well as to localize sites of perforators. It was done while the patient was in supine and standing position to confirm and localize the degree of axial reflux.

All patients received prophylactic low molecular weight heparin (LMWH) the night before the procedure. The patients were examined in anti-Trendelenburg position on the operating table in comfortable room temperature, and vein identification was favorably directed below the knee or above the ankle. An antiseptic was applied on the skin, and it was infiltrated with local anesthesia (1–2% of xylocaine). The vein was accessed by a puncture introducer set, and a 0.35-Fr guide wire was advanced proximally under US surveillance and positioned at the SFJ, as shown in Fig. 1.

Figure 1

Introducing the wire over a 6-Fr sheath 10 cm below the knee level.

Figure 2

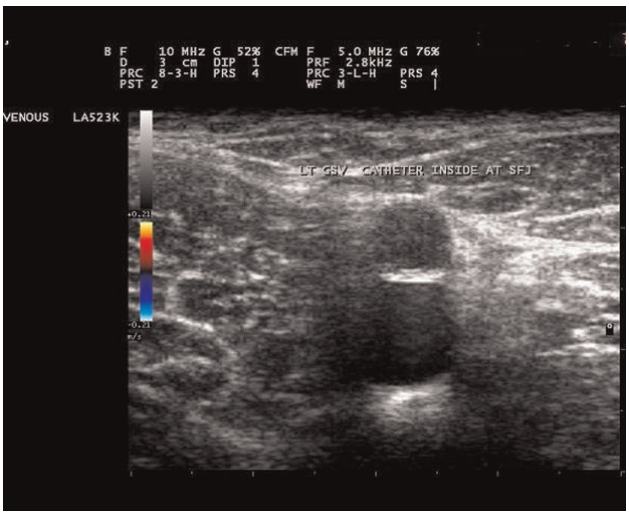


Ureteric catheter (Amecath Medical Technology).

Figure 3

Tessari method for preparation of microfoam.

Figure 4



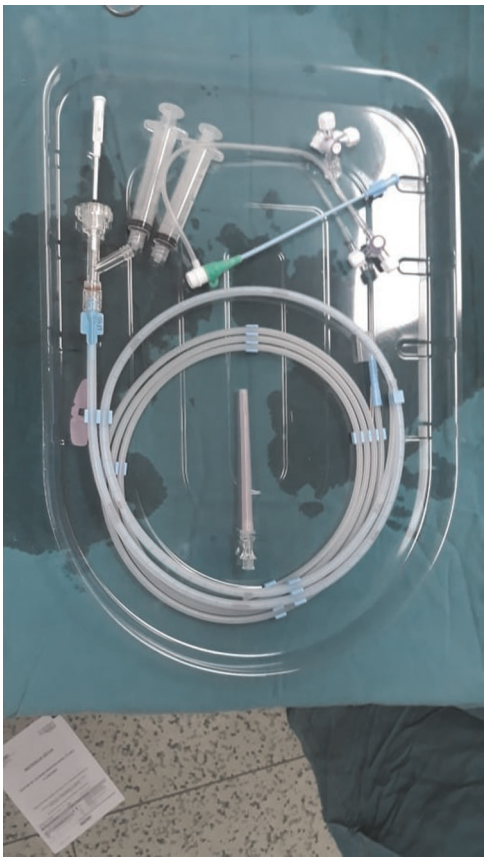
Tip of the catheter reaching SFJ.

In chemical ablation group, we used ureteric catheter (Amecath Medical, Egypt; 5 Fr×90 cm) (Fig. 2), which was inserted over the guide wire and placed about 2 cm distal to the SFJ. The guide wire was withdrawn. The table was tilted for leg elevation (30°) to evacuate the GSV. Injection of saline was performed to see the catheter tip and to confirm a place distal to the SFJ. Using Tessari technique, 10-ml SF was formed by mixture of 2 ml 3% Polidocanol and 8 mm of air utilizing two syringes and a three-way connector (Fig. 3). Then injection started with gradual withdrawal the catheter under US control (amount of injection; 1.5–2 ampules of Aethoxysklerol 3%).

In mechanochemical ablation group, Flebogrif catheter (Balton, Poland, FLE6F90) was used, which was introduced over the guide wire after doing puncture using 18-G needle and positioned ~2 cm distal to the SFJ. The guide wire was withdrawn. The table was to some extent tilted for leg elevation (30°) to empty the GSV. Saline was injected to see the catheter tip and ensure a position distal to the SFJ. The same technique of Tessari was used, as shown in Figs 4 and 5.

The SFJ was compressed with the US probe proximal to the catheter tip, to inhibit inflow from the GSV to the common femoral vein. The sheath was withdrawn to expose the hooks (Fig. 6). The foam (good consistency foam) using sclerosant agent (Aethoxysklerol 3%) was then delivered

Figure 5



Flebogrif catheter (Balton Company).

Table 5 Follow-up results between group A and group B

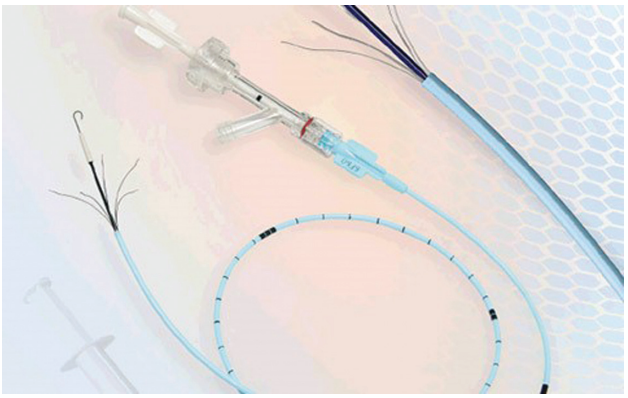
Follow-up results	Group A (*N*=79) [*n* (%)]	Group B (*N*=25) [*n* (%)]	*P* value
After 2 weeks			
Occluded GSV	79 (100)	25 (100)	1
After 3 months			
Complete occlusion	79 (100)	19 (76)	0.001
Partial recanalization	–	6 (24)	
After 6 months			
Recanalization	36 (45.56)	3 (12)	0.003
Maintained complete occlusion	43 (54.43)	22 (88)	

GSV, great saphenous vein.

inside the GSV while the catheter was steadily withdrawn. The withdrawal speed is ~5 cm/s and the volume of the injected foam amounted to 1 ml/5 cm of vein. The SFJ was compressed by the duplex US probe (amount of injection; 1–1.5 ampules of Aethoxysklerol 3%).

All patients were wrapped with two-layer short stretch compression bandages for one week after treatment and advised to walk 30 min after the procedure. The bandages were self-adhesive and kept till removed by the cases at the end of the week.

Figure 6



Catheter beyond saphenofemoral junction.

Table 6 Complications between group A and group B

	Group A [*n* (%)]	Group B [*n* (%)]
Painful thrombophlebitis	20 (25.3)	4 (16)
DVT	1 (1.2)	–
Respiratory distress	1 (1.2)	–
Hyperpigmentation	–	1 (4)

DVT, deep venous thrombosis.

Results

Statistical analysis

Data were analyzed using the SPSS program for Windows (version 21). The normality of data was first assessed with one-sample Kolmogorov–Smirnov test.

Qualitative data were described by utilizing number and percentage. Correlation among categorical variables was tested by utilizing χ^2 test, whereas Fisher exact test and Monte Carlo test were used when expected cell count below 5.

Continuous variables were presented as mean±SD, and Student *t* test was used to compare two groups.

Level of significance

For all the aforementioned statistical tests done, the results were considered significant when the *P* value was less than or equal to 0.05.

The smaller the *P* value obtained, the more significant the results.

After 6 months, success was obtained and achieved in 65 (62.5%) cases of 104 patients (43/79 chemicals+22/25 mechanochemical ablation). Long-segment recanalization occurred in 36/79 (45.56%) cases among chemical ablation group A and partial

Figure 7

Before and after chemical ablation procedure (6-month follow-up).

Figure 8

Before and after mechanochemical ablation procedure (6-month follow-up).

recanalization occurred in 6/25 (24%) cases among mechanochemical ablation group B. They underwent duplex-guided repeated injection, and three (12%) of them reported complete occlusion, as shown in Tables 5 and 6 and Figs 7 and 8.

Regarding visual numerical pain score, 25 (31.64%) cases reported mild pain intensity, 36 (45.56%)

Table 7 Pain score using visual analog scale between group A and group B

	Group A (*N*=79) [*n* (%)]	Group B (*N*=25) [*n* (%)]
Mild (0–4)	25 (31.64)	16 (64)
Moderate (5–6)	36 (45.56)	7 (28)
Severe (7–10)	18 (22.78)	2 (8)

patients reported moderate pain intensity, and 18 (22.78%) cases reported severe pain intensity among group A, whereas 16 (64%) cases reported mild pain intensity, seven (28%) cases reported moderate pain intensity, and only two (8%) cases reported severe pain intensity among group B (Table 7).

Regarding patient satisfaction, 17 (21.51%) cases were very satisfied, 23 (29.1%) cases were satisfied, and 39 (49.36%) were not satisfied among group A, whereas 16 (64%) cases were very satisfied, seven (28%) cases were satisfied, and only two (8%) cases was not satisfied among group B, as shown in Tables 8 and 9.

Discussion

This prospective, nonrandomized, comparative study was conducted on 104 patients divided into two groups: chemical ablation (group A) and mechanochemical ablation (group B). They were treated with catheter-directed foam sclerotherapy for axial vein reflux in the lower limbs.

In our study, we conducted chemical ablation using catheter-directed foam sclerotherapy on 79 patients from 2017 to 2019. This relatively small number of patients in this period in comparison with other studies may be owing to strict adhesion to consent and explanation to the patients this new technique with relatively higher incidence of recurrence. Moreover, the selection of vein diameter was relatively wide in many patients, which exceeded the maximum diameter selected in other studies (12 mm in supine position which reached 15 mm in standing position). Devereux and colleagues, conducted their study in diameter range of 6.46 (5.0–9.7) and 6.59 (5.0–9.6) in two groups of patients; Iłżecki *et al.* [12], also conducted their study in vein diameter of 6–8 mm; and Bayoumi *et al.* [13], conducted their study in vein diameter of 5–10 mm.

A small number of patients underwent mechanochemical ablation (25 patients) because of relatively high cost of the catheter, which many of our patients cannot afford the cost and the hospital did not support this type of therapy; moreover, the female sex predominance in group B was owing to the preference of the women to this new technique.

The clinical success rates at 6-month follow-up as preliminary results are comparable to other studies on foam sclerotherapy through direct puncture of the axial veins using needle and syringe [14,15]. Our study showed a number of advantages: the vasospasm of the vein is maximum owing to presence of the catheter inside the vein lumen. Moreover, elevation of the limb and low injection pressure are two important factors in distribution of the foam inside the whole vein length [16]. Rather interesting, in our study, we used minimal amount of foam with minimal pressure, which allows efficiency of the technique and reduced risk of thromboembolism, which is compatible with the opinion reported by Saleh [17].

Taking into consideration our capability to approach below the knee in chemical ablation in comparison with thermal ablation techniques, which cannot approach below the knee, it is an advantage. Moreover, the procedure takes very short time, is a rapid process, and no tumescent is used. In addition, there are no repeated punctures for tumescent injection and no time consumption. Additionally, diffusion of the foam into incompetent perforators and surrounding varicosities was noticed during the procedure, eliminating the need for further intervention, which is also a major advantage.

Evidence from the obtained results in 6-month follow-up demonstrated the highly efficacious nature of the

Table 8 Patient satisfaction score among group A and group B

	Group A (*N*=79) [*n* (%)]	Group B (*N*=25) [*n* (%)]
Very satisfied	17 (21.51)	16 (64)
Satisfied	23 (29.1)	6 (24)
Nonsatisfied	39 (49.36)	3 (12)

Table 9 Comparison between group A and group B regarding success, complications, pain score, and patient satisfaction

	Chemical: group A (*N*=779) [*n* (%)]	Mechanochemical: group B (*N*=25) [*n* (%)]	*P* value
Success	43 (54.43)	22 (88)	0.002
Complications	22 (27.84)	5 (20)	0.690
Pain score	Mild: 31.64% Moderate: 45.56% Severe: 22.78%	Mild: 64% Moderate: 28% Severe: 8%	0.008
Patient satisfaction	Very satisfied: 21.51% Satisfied: 29.1% Nonsatisfied: 49.36%	Very satisfied: 64% Satisfied: 24% Nonsatisfied: 12%	<0.001

procedure. Although 39 (37.5%) of 104 patients experienced recanalization (36/79 chemicals+3/25 mechanochemical), which was more in group A than group B, the low number of complications, cosmetic effect, and patient satisfaction widely accepted by patients (especially in group B) allowed us to add this method to the list of minimally invasive procedures and should be seriously considered by medical professionals treating superficial vein insufficiencies.

High failure rate in group 'A' in our study is not compatible with other studies. It is justifiable to assume the following:

(1) Wider diameter of the GSV in our study '12 mm in supine position which may reach 15 mm in standing position.'
(2) Use of tumescence in other studies, which had a great role in vein spasm and obtaining better results, like Devereux *et al.* [18], who reported full occlusion in 73.9% of cases.
(3) We did not comment on partial success, and we considered partial success as failure, whereas other studies considered it success, such as Saleh [17], who reported success in 92% of patients as a preliminary result, and also Lindblad and Kölbel [19], who reported success in 72% of cases.Low incidence of early adverse effect in foam sclerotherapy group was reported, which may be attributable to the vasospasm of the treated vein induced by presence of the catheter and also manual compression at the saphenofemoral using duplex probe, which keep the foam inside the superficial venous lumen and prevent escape of the foam to the deep venous system [20].

The immediate complications were few, and no cases reported visual disturbance, nausea, vomiting, and vasovagal attacks.

Our proposed method of endovascular mechanochemical GSV ablation is an effective, minimally invasive treatment of venous insufficiency. The model pathological mechanism of mechanochemical ablation method is based on shrinking of the veins and the resultant fibrosis owing to the inflammatory process as a consequence of chemical damage to the endothelium initialized by mechanical injury of the vessel wall. Previous studies on this technique reported success in 92 and 94% of cases, as reported by Iłżecki *et al.* [12], and Soliman [21].

Conclusions

To the best of our knowledge, it is the first study conducted as intention to treat to evaluate the effectiveness of chemical ablation and mechanochemical ablation of the GSV. It is not a head-to-head study with endovenous laser ablation (ELVA) or radiofrequency ablation (RFA), but the method of mechanochemical ablation is more effective, influential, less recurrence, less amount sclerosant used, more convenient, less pain score, and more patient satisfaction.

In conclusion, the catheter-directed foam sclerotherapy is accepted as a technique for varicose vein foam sclerotherapy with initial and short-term success in vein obliteration and has a very low numbers of complications, low cost, and better patient satisfaction.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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