Comparison of endovenous microwave ablation versus radiofrequency ablation for lower limb varicose veins

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ABSTRACT

Objective: Endovenous microwave ablation (EMA) is a recently developed thermal ablation technique used in the treatment of lower limb varicose veins. However, its efficacy and safety have been largely understudied. In the present study, we sought to explore the clinical results of EMA and radiofrequency ablation (RFA) in treating lower limb varicose veins.

Methods: Patients who underwent EMA (n = 65) or RFA (n = 46) at our institute from September 2018 to September 2020 were included in this retrospective investigation. The clinical results and complications were evaluated at 1, 3, 6, and 12 months after the procedure. The effects on disease severity and quality of life were evaluated using the venous clinical severity score and chronic venous insufficiency questionnaire (CIVIQ).

Results: The technical success rate was 100% for both experimental groups. Although the operative time between the two groups was comparable, the EMA technique was associated with lower direct costs ($P < .001$), although also with prolonged hospitalization ($P < .001$). We found that the use of EMA correlated with more pain at 48 hours postoperatively. Except for the visual analog scale scores, no statistically significant variations were observed in the occurrence of postoperative complications within the first 48 hours postoperatively between the EMA and RFA groups, including paresthesia, ecchymosis, induration, and phlebitis ($P > .05$). At 4 weeks postoperatively, significantly less pigmentation was observed in the RFA group than in the EMA group (13.04% vs 32.31%; $P = .020$). However, the pigmentation had resolved in all patients by 12 months postoperatively. The two groups had a reduction in the venous clinical severity scores and an increase in the CIVIQ scores after the procedure. However, the CIVIQ scores within the RFA group had increased more than had those within the EMA group ($P < .05$). No significant differences were found in recurrence between the two groups (EMA group, 1.54%; RFA group, 2.17%; $P = .804$).

Conclusions: Both ablation techniques are safe and effective. RFA is associated with relatively higher treatment costs but shorter hospitalization and better quality of life improvement. (J Vasc Surg Venous Lymphat Disord 2024;12:101662.)

Keywords: Complications; Efficacy; Endovenous microwave ablation; Lower limb varicose veins; Radiofrequency ablation

Lower limb varicose veins (LLVVs) are a prevalent vascular condition that affects approximately one third of the adult population, especially those working mostly in a standing position, participating in high-intensity physical activities, or experiencing extended periods of physical inactivity.[1] A considerable proportion of patients will experience itching, pigmentation, occasional discomfort, and skin ulceration, severely affecting their quality of life (QoL).[2]

In recent years, endovenous procedures have achieved significant popularity as a less invasive alternative to high ligation and stripping for managing chronic venous insufficiency and are now considered the standard of care. The two forms of treatment are primarily endovenous thermal ablation (ETA) and nonthermal ablation (foam, mechanical occlusion chemically assisted ablation, and cyanoacrylate ablation).[3-6] In recent years, ETA, including endovenous laser ablation and radiofrequency ablation (RFA) techniques, have gained prominence as the preferred initial intervention for LLVVs globally, with foam sclerotherapy as second-line treatment.[5,7] It has been established that endovenous procedures are associated with faster recovery and enhanced QoL and result in reduced adverse effects compared with conventional surgical treatment. Mechanical occlusion chemically assisted

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ablation and cyanoacrylate ablation require additional research to prove their safety, efficacy, and durability, although they have undeniable promise.[4,6] At present, ETA combined with foam sclerotherapy has replaced conventional surgery and become the mainstream method for the treatment of LLVVs.[6,8,9]

In 2009, Subwongcharoen et al[10] reported the first human application of endovenous microwave ablation (EMA) for the treatment of great saphenous vein (GSV) incompetence, which was followed by several reports on the efficiency of EMA for the treatment of LLVVs.[11-13] EMA is a new heat therapy that could provide a endogenous heat source by closure of the and causes more complete closure of the entire layer of the vein without damaging the surrounding tissue, whose solidification of heat has the advantages of high thermal efficiency, fast temperature increase, uniform tissue heat, moderate thermal penetration, no obvious short-term carbonization, and easy regulation of the thermal solidification range for a 1-cm heating zone compared with other thermal methods. The variance in the mechanism of action could affect the safety and effectiveness of these experiments differently. However, few clinical studies have compared EMA and RFA. Therefore, in the present retrospective review, we aim to assess the safety and efficacy of EMA in treating LLVVs compared with RFA in the immediate, short-, and medium-term outcomes.

ARTICLE HIGHLIGHTS

- **Type of Research:** A single-center retrospective cohort study of prospectively collected outcomes data of two ablation procedures
- **Key Findings:** Both endovenous microwave ablation and radiofrequency ablation are safe and effective for lower limb varicose veins (LLVVs). The long-term outcomes of our study warrant further validation in randomized controlled trials.
- **Take Home Message:** LLVVs are common vascular diseases that affect up to one third of adults. Endovenous thermal ablation has become the recommended first-line treatment and foam sclerotherapy the second-line treatment of LLVVs worldwide owing to the quicker recovery time and fewer complications compared with traditional surgery. This single-center retrospective cohort study has delineated the outcome differences between two ablation techniques in terms of clinical safety and efficacy.

METHODS

Patients. A total of 127 patients with LLVVs were referred to our institute for endovenous treatment from September 2018 to September 2020. The diagnosis of LLVV was established from the clinical presentation and venous ultrasound examination findings, including the GSV, small saphenous vein (SSV), lower limb deep veins, accessory saphenous vein (ASV), and perforator vein (PV). The clinical severity was determined using the CEAP (clinical, etiologic, anatomic, pathophysiologic) classification. The indications were symptomatic LLVV, CEAP class C2 to C6, and endovenous thermal treatment.

The criteria for inclusion were as follows: symptomatic LLVVs (CEAP class C2-C6); GSV, SSV, or ASV incompetence, also validated as a reflux time of ≥0.5 second on Doppler ultrasound; pathologic PVs, also validated as a reflux time of ≥0.5 second and a diameter of ≥3.5 mm underneath a healed or active ulcer on ultrasound[5]; and the use of EMA or RFA for the treatment of LLVVs for symptoms such as swelling, pain, stasis dermatitis, and stasis ulcer. The criteria for exclusion were as follows: suspected or proven deep vein thrombosis or occlusion; deep vein reflux to a distal limb; contraindications to anesthesia and surgery; and refusal to participate in the investigation. All patients included in the study were hospitalized for treatment. The treatment modality was randomized; however, the patient's willingness also needed to be considered because of the cost.

The institutional review board of The Fifth Affiliated Hospital at Sun Yat-sen University approved the present study, which adhered to the standards outlined in the Declaration of Helsinki. All the included patients provided written informed consent.

Endovenous ablation therapy. Before beginning surgery, a comprehensive assessment was conducted to identify and establish all tributaries and varices. The precise location of each varix was meticulously documented to facilitate postoperative evaluations and comparisons. All the procedures in both groups were conducted after administration of tumescent anesthesia. Tumescence was administered as a standard procedure to all patients, using a solution consisting of 0.9% saline containing 20 mL of 2% lidocaine with 1:200,000 adrenaline and 20 mL of 0.5% levobupivacaine in 1 L of 0.9% saline. The total dosage of local anesthetic administered to each patient remained within the prescribed maximum safety limit.

Endovenous RFA. After administration of the local anesthetic, a 7F vascular sheath (Cook Medical Inc) was cannulated into the GSV and/or ASV or the GSV and/or SSV, either slightly above or below the knee, with ultrasound guidance at the beginning of the procedure. An RFA catheter (Closure Fast; Covidien) was inserted into the sheath and guided by ultrasound to a depth of 2 to 3 cm under the saphenofemoral or saphenopopliteal junction. If the GSV and/or ASV or the GSV and/or SSV were too tortuous for direct advancement, a 0.018-in. guidewire (V-18; Boston Scientific) and 4F

angiographic catheter (VER; Cordis) were inserted into the GSV and/or ASV or the GSV and/or SSV. Once the guidewire reached the common femoral vein, the angiographic catheter was replaced by the RFA catheter and the catheter's tip was localized within 2 to 3 cm under the saphenofemoral or saphenopopliteal junction.

Tumescent anesthesia was given under ultrasound guidance along the GSV and/or ASV or the GSV and/or SSV at a dosage of 10 mL per 1-cm length. The heating element was energized to a temperature of 120°C for a duration of 20 seconds, which was achieved by pulling out the catheter at regular 6.5-cm intervals.

EMA procedure. After cannulation of the GSV and/or ASV or the GSV and/or SSV, a microwave catheter (ECO-100F-2016; Nanjing ECO) was positioned at a site 2 to 3 cm under the saphenofemoral or saphenopopliteal junction using a method identical to that used for RFA. Ablation of the GSV and/or ASV and ablation of the GSV and/or SSV was performed using a pulse mode at 60 W for 6 to 8 seconds under tumescent anesthesia. The microwave catheter was pulled out at intervals of 2.0 cm based on our own experience.

Management of PVs and superficial varices below the knee. All pathologic PVs were ablated using a short RFA probe (L-212; Medsphere) and subjected to puncture across normal skin close to the ulcer. With the power set at 20 W and a 2 to 4 mm withdrawal speed per second, the PVs were ablated under tumescent anesthesia.

Foam sclerotherapy was used to treat residual superficial LLVVs below the knee during the procedure.[6,8,9] The foam was manually generated by the use of two interconnected sterile disposable syringes. One syringe was filled with 2 mL of Lauromacrogol (Tianyu) and the second with 8 mL of air. The foam was produced by combining the drug and air in a proportion of 1:4. The drug was injected into the superficial LLVVs and dosages is based on the range of superficial LLVVs, the foamy sclerosant never exceeded 15 mL.

Postprocedure management. After completion of the surgery, the limbs of the patients in both cohorts were wrapped with aseptic bandages, which were subsequently coated with a self-adhesive compression bandage for 48 hours, with the purpose of sustaining an optimal level of therapeutic compression pressure. Subsequently, the patients were provided with explicit instructions to wear an ankle medical compression stocking (20-30 mm Hg pressure) only during the day for a minimum of 4 weeks. The ulcers were wrapped with sterile gauze, which was replaced at intervals of 3 days.

Follow-up. The patients were scheduled for follow-up appointments at the outpatient clinic at 1, 3, 6, and 12 months after surgery. During these appointments, the outcomes of the ablation procedures were evaluated by Doppler ultrasound examinations. Participants who did not attend a follow-up visit were reached via telephone.[14] The patient satisfaction rating for both groups was assessed and documented at the 12-month point.

Complications. According to the recommendations of the Society of Interventional Radiology,[15] complications can be classified as mild or severe. Procedure-related complications include pain, ecchymosis, paresthesia, induration, phlebitis, deep vein thrombosis, and pulmonary infarction. Severe complications include serious infections, deep vein thrombosis, pulmonary embolism, cases requiring emergency surgical treatment, and death.

The postoperative pain intensity was measured using a visual analog scale (VAS) with a score ranging from 0 to 10. A score of 0 denoted the absence of pain and a score of 10, the highest level of pain.[16] The presence of ecchymosis was verified 48 hours after surgery on observation of a congestion region >2 cm^2 in the limbs that were impacted. The presence of paresthesia in the vicinity of the ablated region was documented from information obtained from the patient's medical records and a comprehensive physical assessment.

Outcome measures. Technical success was defined as a closed GSV and/or ASV or a closed GSV and/or SSV, with the absence of flow after surgery. Clinical success was characterized as the successful conclusion of LLVVs on Doppler ultrasound at 1 month postoperatively and the healing of ulcers if present before the procedure.[17] Treatment was considered to have failed if a portion of the vein that had undergone treatment was open and >10 cm.

Recurrence was established using both Doppler ultrasound and clinical assessment. A previously unobserved varicose vein was identified as a recurrent varicose vein (due to neovascularization or dilation of preexisting veins).[18,19] The technical success, clinical success, body mass index, operative time (from the start of anesthetic administration to completion of leg wrapping), diameter of the treated vein, cost and length of hospitalization, and incidence of recurrence and complication were recorded.

Severity and QoL evaluation. The severity of specific effects of the disease and QoL were assessed using physician- and patient-reported disease-specific questionnaires: the venous clinical severity score (VCSS)[7] and chronic venous insufficiency questionnaire (CIVIQ),[20] respectively. These are considered confirmed tools for the evaluation of disease severity and QoL for patients with LLVVs and were completed preoperatively and at 1, 3, 6, and 12 months postoperatively. The

severity of specific effects was evaluated using the VCSS, with a score ranging from 0 to 30. Higher scores correspond to a greater degree of severity. The CIVIQ score ranges from 0 to 70, with greater scores denoting superior QoL.

Statistical analysis. The data were obtained at the preoperative hospitalization and subsequent follow-up visits and analyzed using SPSS, version 13.0 (IBM Corp). A P value $< .05$ was considered to indicate statistical significance. Categorical data were evaluated using a χ^2 test, and continuous data were initially examined for normality. Normally distributed data are reported as the mean ± standard deviation and were evaluated using an independent t test. Data with a nonparametric distribution are presented as the median and interquartile range and were analyzed using the Mann-Whitney U test for independent samples and the Wilcoxon signed rank test for paired data.

RESULTS

Baseline characteristics. A total of 111 participants (141 limbs) were included in the present single-center retrospective investigation. Of the 111 patients, 65 (73 limbs) underwent EMA and 46 (68 limbs) underwent RFA. No statistically significant variations were observed in the baseline and demographic features across the two groups ($P > .05$). In the EMA group, six patients had a documented medical history of surgical intervention on a particular target lesion, including two patients who had undergone sclerotherapy 1 year previously and four patients who had undergone ligation and stripping of the GSV 2 to 7 years previously. In the RFA group, one patient had a history of ligation and stripping of the GSV 3 years previously. The demographic characteristics, CEAP classification, and other details were similar between the two groups (Table I).

Clinical results. The technical success rate was 100% for both groups, with all patients attending outpatient follow-up. With a comparable operative time between the two groups, the EMA technique was associated with lower surgical and hospitalization-related costs but the patients required hospitalization for a longer period (Table II).

All patients were followed up during the outpatient visits, and the clinical results were evaluated using

Table I. Demographic data and additional details for both groups

	EMA	RFA	*P* value[a]
Gender			.55
Female	33	26	
Male	32	20	
Age, years	53.54 ± 11.98	52.02 ± 12.32	.518
BMI, kg/m^2	24.72 ± 3.87	24.27 ± 3.38	.524
CEAP			.753
C2	18	11	
C3	12	15	
C4	22	11	
C5	6	3	
C6	7	6	
Target vessel			
GSV	62 (95.85)	46 (100)	.230
SSV	3 (4.62)	2 (4.35)	.947
ASV	6 (9.23)	4 (8.70)	.923
PV	1 (1.54)	1 (2.17)	.232
Target vessel diameter, mm			
GSV	8.0 (7.3-9.65)	8.3 (8.0-9.0)	.436
ASV	5.05 (3.675-6.325)	4.8 (3.35-6.775)	.915
SSV	–	–	–
PV	–	–	–
Previous treatment	5 (7.69)	1 (2.17)	.205

ASV, Accessory saphenous vein; *BMI,* body mass index; *CEAP,* clinical, etiologic, anatomic, pathophysiologic; *EMA,* endovenous microwave ablation; *GSV,* great saphenous vein; *PV,* perforator vein; *RFA,* radiofrequency ablation; *SSV,* small saphenous vein.
Data presented as number, mean ± standard deviation, number (%), or median (interquartile range).
[a]EMA vs RFA.

Table II. Medical details during hospitalization in both groups

Variable	EMA	RFA	*P* Value[a]
Operative time, minutes	80 (66.5-94.5)	70 (55-91.75)	.102
Hospitalization, days	5 (3-6)	4 (3-5)	<.001
Direct cost, RMB yuan	16,771 (16276-17,193)	19,658 (17,819-22,230)	<.001
Indirect cost, RMB yuan	5929 (4836-7998)	4371 (3883-8108)	.084

EMA, Endovenous microwave ablation; *RFA,* radiofrequency ablation; *RMB,* renminbi.
Data presented as median (interquartile range).
[a]EMA vs RFA.

Doppler ultrasound at 1, 3, 6, and 12 months postoperatively. Complete occlusion was noted using Doppler ultrasound at 1 month postoperatively in all patients. Thus, the clinical success rate was 100% in both groups.

Recurrent LLVVs were found at 6 months postoperatively in one limb in each group, which presented as reflux of the ASV on Doppler ultrasound that had not been observed before the procedure. No statistically significant variations were observed in the recurrence rates between the two groups (EMA group, 1.54%; vs RFA group, 2.17%; $P = .804$). No recanalization or neovascularization was required in either group.

Complications. The complications related to the procedure included pain, ecchymosis, paresthesia, induration, phlebitis, and pigmentation. No serious adverse effects associated with the surgery were observed in either group.

Except for the VAS scores, which showed that patients undergoing EMA experienced more pain at 48 hours postoperatively, no statistically significant difference in the occurrence of adverse effects within 48 hours was observed between the two groups. Ecchymosis, induration and phlebitis had resolved at 4 weeks after the procedure, and paresthesia had resolved in all the patients at 6 months (Table III).

At 4 weeks after the procedure, significantly less pigmentation was observed in the RFA group than in the EMA group (13.04% vs 32.31%; $P = .020$). At 12 months after the procedure, the pigmentation had resolved in all the patients.

Severity and QoL assessment. Severity and QoL were evaluated using the VCSS system and CIVIQ scoring system, with no statistically significant variations observed at baseline between the two groups ($P > .05$). Postoperatively, both groups exhibited a reduction in the VCSSs and an increase in the CIVIQ scores ($P < .01$; Fig). Except for the VCSSs at 6 months, no statistically significant variations were found between the two groups at any other point ($P > .05$; Table IV). However, the CIVIQ scores in the RFA group were higher than those in the EMA group after the procedure ($P < .05$; Table V).

DISCUSSION

The results from the present study provide confirmation of the comparable clinical results between EMA and RFA, with decreased VCSSs and increased CIVIQ scores after treatment and no recanalization detected using Doppler ultrasound. These findings corroborate that EMA is an efficient technique to treat LLVVs.

A previous study showed that the thermal injury zones created by RFA and EMA appeared similar on gross and microscopic pathologic evaluation.[21] However, the EMA technique uses distinct thermal mechanisms compared with the RFA procedure. During application of RFA, a small zone of active heating around the probe is generated via ionic agitation (on the order of a few millimeters).[22] During treatment, the effectiveness is attributed to the occurrence of venous spasms resulting from shrinkage of the venous wall caused by the application of heat. Also, most tissue heating during RFA is caused by thermal conduction.[23] During EMA, the microwave is used to emit microwave energy by antenna radiation. This energy causes the polar molecules inside the vascular tissues to vibrate at a high frequency when exposed to a microwave field. Consequently, heat is generated directly as a result of this phenomenon,[11] which solidifies the tissue promptly (in just a few seconds) at a high temperature and closes the LLVVs quickly. In addition, it is widely believed that EMA relies less on thermal

Table III. Complications at 48 hours postoperatively in both groups

Complication	EMA	RFA	*P* value[a]
Pain	27 (41.54)	16 (34.78)	.302
VAS score			.001
1	12	9	
2	9	5	
3	4	2	
4	2	0	
Paresthesia	6 (9.23)	1 (2.17)	.132
Ecchymosis	22 (33.85)	14 (30.43)	.433
Induration	2 (2.308)	1 (2.17)	.773
Phlebitis	2 (2.308)	1 (2.17)	.773

EMA, Endovenous microwave ablation; *RFA,* radiofrequency ablation; *VAS,* visual analog scale.
Data presented as number (%).
[a]EMA vs RFA.

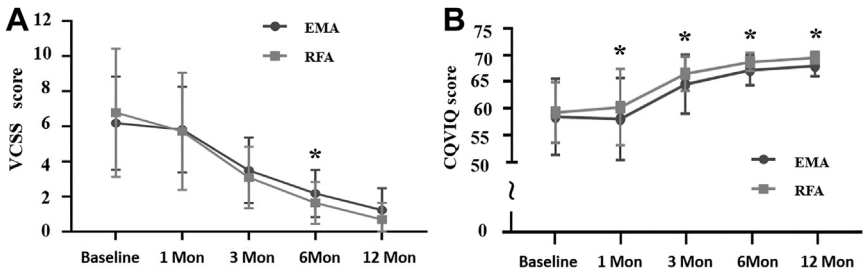

Fig. Venous clinical severity scores (VCSSs) and chronic venous insufficiency questionnaire (CIVIQ) scores of patients who underwent endovenous microwave ablation (EMA) or radiofrequency ablation (RFA). **A,** VCSSs were assessed preoperatively and 1, 3, 6, and 12 months postoperatively. **B,** CIVIQ scores were assessed preoperatively and 1, 3, 6, and 12 months postoperatively. Data presented as median and interquartile range. *Mon,* month; *MWA,* microwave ablation. *$P < .05$ compared with baseline.

conduction. Compared with RFA, EMA exhibits a significantly greater zone of active heating. The extent of this active heating region is dependent on the wavelength of the energy used.[24,25]

The differences in pigmentation at 4 weeks after the procedure and the experience of postoperative pain related to the procedure might correlate with the mechanisms of the devices. The probe achieves accurate temperature control using impedance modulation and feedback corrections during the RFA procedure to avoid excessive "burn" to the tissue. In contrast, EMA has significant features such as elevated thermal efficiency, swift heating, and moderate thermal penetration. These properties result in the direct application of thermal destruction on the vessel walls and surrounding tissue, which could increase the risk of heat-induced impairment without the technique of impedance modulation and feedback corrections present with RFA. Therefore, it is crucial for an experienced surgeon to perform EMA to treat LLVVs. In the present study, the postoperative VAS scores for the EMA group were higher than those for the RFA group. Also, more pigmentation was present in the EMA group, which might have resulted in longer hospital stays and lower CIVIQ scores during the follow-up period. However, a standardized dosage regimen has not yet been determined for the EMA system, with no cases of skin burn in the EMA group.

In addition to postoperative pain, the thermal ablation techniques used to treat LLVVs often lead to heat-associated adverse effects, including nerve injury, skin burns, and induration. The findings of the present investigation indicate that the EMA technique has a low occurrence of induration, ecchymosis, and paresthesia, comparable to the incidence with the RFA technique. Moreover, the use of the tumescent anesthetic technique has the potential to decrease the occurrence of thermal injury and is recommended as a standard approach for thermal ablation therapy.

During clinical practice, ablation of the trunk of the GSV and/or ASV is often performed above the knee to reduce the incidence of saphenous nerve damage. However, thermal destruction has the potential to induce transient nerve damage due to the heat conduction effect. In the present study, paresthesia was observed during the perioperative and follow-up periods. However, paresthesia of the ablation zone had been mostly alleviated at 3 days to 3 months after the procedures and had completely resolved within 6 months after both procedures without further therapy. Furthermore, it is imperative to perform thermal ablation on the entire

Table IV. Venous clinical severity score (VCSS) for both groups

Time point	VCSS		*P* value[a]
	EMA	RFA	
Baseline	6 (4-7)	6 (4-8.5)	.692
1 Month	5 (4-7)	5 (3-7)	.261
3 Months	3 (2-4.5)	3 (2-4)	.217
6 Months	2 (1-3)	1 (1-2)	.023
12 Months	1 (0-2)	1 (40-1)	.139

EMA, Endovenous microwave ablation; *RFA,* radiofrequency ablation. Data presented as median (interquartile range).
[a]EMA vs RFA.

Table V. Chronic venous insufficiency questionnaire (CIVIQ) scores for both groups

Time point	CIVIQ score		*P* value[a]
	EMA	RFA	
Baseline	60 (55.5-62.5)	60 (56.75-63)	.757
1 Month	60 (56.5-60)	63 (59-64)	.029
3 Months	66 (63.5-68)	68 (65-68.25)	.018
6 Months	68 (66-69)	69 (68-70)	.001
12 Months	68 (67-70)	70 (69-70)	<.001

EMA, Endovenous microwave ablation; *RFA,* radiofrequency ablation. Data presented as median (interquartile range).
[a]EMA vs RFA.

lower LLVVs. However, it is possible to mitigate the thermal damage by using lower ablative energy levels and augmenting the use of tumescent anesthesia.

Because the RFA probe and EMA antenna were difficult to bend, it was challenging to insert either into tortuous LLVVs below the knee. The use of foam sclerotherapy is important for treating residual LLVVs below the knee during the procedure.[26,27] In our study, foam sclerotherapy was performed under ultrasound guidance. Foam sclerotherapy occluded the tortuous varices around the ulcers effectively, which promoted ulcer healing. Although the foam volume used in our study was more than the recommended volume,[26] no complications were encountered.

Using the technique of impedance modulation and feedback correction, the RFA device provides more safety and convenience during the procedure. However, our results indicate that RFA is a more costly therapeutic option, and many Chinese patients cannot afford the expensive treatment fees. Based on our experience, the optimal power for treating the GSV and/or ASV or the GSV and/or SSV trunks with EMA in pulse mode is 60 W for 6 to 8 seconds. These power settings ensure an adequate rate of closure for LLVVs and mitigate the risk of severe thermal damage, in accordance with the literature.[8,12]

Study limitations. Our study had a number of restrictions and weaknesses. Initially, our investigation was retrospective, with no randomization for treatment allocation. The patients were allowed to choose the treatment; thus, introducing a potential source of selective bias. In addition, the present study had a limited sample size, with an asymmetric distribution between the two groups. Moreover, the duration of the follow-up period was insufficient to adequately evaluate the long-term effects and efficacy.

CONCLUSIONS

Our results show that both ablation techniques are safe and effective. However, RFA is associated with relatively higher treatment costs, although it results in shorter hospitalization stays and better QoL improvement. The long-term outcomes of this study warrant further validation in randomized controlled trials.

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AUTHOR CONTRIBUTIONS

Conception and design: NZ, HG, YZ, XH, JH, DW, WH, HG, PP
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