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A Study of Endovascular Laser Ablation for Varicose Veins Treatment - An Observational Study

[1]Suma Wagh, Department of Radiodiagnosis, Dr. Vithalrao Vikhe Patil Foundation's Medical College and Hospital, Ahilyanagar

[1]Dhananjay Wagh, Department of Radiodiagnosis, Dr. Vithalrao Vikhe Patil Foundation's Medical College and Hospital, Ahilyanagar

[1]Gaikwad D C, Department of Radiodiagnosis, Dr. Vithalrao Vikhe Patil Foundation's Medical College and Hospital, Ahilyanagar

Corresponding Author: Suma Wagh, Department of Radiodiagnosis, Dr. Vithalrao Vikhe Patil Foundation's Medical College and Hospital, Ahilyanagar

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Abstract

Background: Varicose veins, a prevalent manifestation of chronic venous insufficiency, significantly impair quality of life due to pain, swelling, and ulceration. Endovenous laser ablation (EVLA) is a minimally invasive treatment that has emerged as an alternative to traditional surgical methods, offering reduced recovery time and improved cosmetic outcomes.

Objective: This study aimed to evaluate the safety, efficacy, and adverse effects of EVLA in treating symptomatic varicose veins.

Methods: An observational descriptive study was conducted at a tertiary care hospital, enrolling 81 patients with varicose veins (CEAP C3–C6) treated with EVLA. Pre-procedural duplex ultrasound (DUS) mapped incompetent veins, and EVLA was performed using a 1470-nm diode laser with tumescent anesthesia. Outcomes, including vein occlusion, complications, and recurrence, were assessed via clinical evaluation and DUS at 1 week, 4 weeks, and 3 months post-procedure.

Results: Complete great saphenous vein ablation was achieved in 98% of cases, with no recanalization at 3 months. Complications were minimal, with deep vein thrombosis in 1.1%, paresthesia in 5.5%, and recurrence in 4.4%. Transient adverse effects included induration (30%), ecchymosis (22.2%), and skin burns (7.7%). Patients reported low postoperative pain (VAS 1.9–2.8 in 76.5%) and rapid ambulation (3.2–4.1 hours in 43.2%), with ulcer healing within 3.8–4.8 weeks in 36.6% of CEAP C6 cases.

Conclusion: EVLA is a safe and effective treatment for varicose veins, with high success rates, low complication rates, and significant improvements in quality of life, supporting its use as a first-line therapy over traditional surgery.

Keywords: Complications, EVLA, Swelling, Varicose Veins

Introduction

Lower extremity venous insufficiency, also referred to as reflux or venous incompetence, is a condition

characterized by a disruption in the normal unidirectional flow of blood back to the heart, resulting in bidirectional flow. This occurs due to dysfunction or damage of the thin, flexible valves that are typically present in peripheral veins and are responsible for preventing the backward flow of blood. Contributing factors to venous insufficiency include lifestyle influences, central venous hypertension, venous thrombosis, or inherited structural abnormalities such as a reduced number or increased fragility of venous valves[1]. When valve function is compromised, it leads to venous incompetence, resulting in localized or widespread venous hypertension, vein dilation, tissue swelling, and altered tissue perfusion.

One of the most recognizable manifestations of superficial lower extremity venous insufficiency is the appearance of varicose veins—dilated, twisted veins that are visible under the skin. These may involve the great or small saphenous veins, perforator veins, or even small subcutaneous venules. The underlying cause may be the direct incompetence of these veins or malfunctioning perforators that transmit high pressure from the deep venous system to the superficial veins.

The venous system is inherently more complex than the arterial system[2]. Efficient venous return from the lower limbs depends on the coordinated function of the heart, a favorable pressure gradient, leg muscle pumps, and intact venous valves. Anatomically, the venous system of the lower extremities consists of three main components: the deep veins (located beneath the muscle fascia, draining muscular structures), the superficial veins (located above the fascia, draining the skin and subcutaneous tissues), and the perforator veins (which traverse the fascia to link the superficial and deep systems)[2]. Additionally, communicating veins serve to connect veins within the same anatomical compartment.

Saphenous vein insufficiency is a common cause of lower extremity venous disease and has a significant negative impact on patients' quality of life[3]. Traditionally, this condition was managed through surgical methods such as high ligation and vein stripping, which often required hospital stays, extended recovery periods, and carried risks of complications like wound infections, hematomas, and deep vein thrombosis. The development and application of duplex ultrasound (DU) enhanced anatomical understanding of truncal vein incompetence and paved the way for minimally invasive treatments such as endovenous laser ablation (EVLA). EVLA effectively eliminates venous reflux with fewer complications, faster recovery times, and better cosmetic outcomes, making it the preferred treatment over the last decade. It is now routinely performed as an outpatient procedure.

However, one of the more uncomfortable aspects of EVLA for patients is the administration of multiple tumescent anesthesia (TA) injections along the great saphenous vein (GSV), which are essential to protect surrounding tissues from thermal injury and reduce procedural pain. To address this issue, newer endovenous techniques are being developed specifically to bypass the need for tumescent anesthesia. In this context, regional nerve blocks have also been utilized in both varicose vein surgery and EVLA procedures[4].

Materials and Methods

The aim of this study was to investigate the safety, efficacy, and adverse effects of endovenous laser ablation (EVLA) as a treatment for varicose veins, with the goal of determining its suitability as a minimally invasive alternative to traditional surgical methods. The primary objective was to evaluate the outcomes and adverse effects of EVLA in patients with symptomatic varicose veins, focusing on procedural success (complete vein

ablation), complication rates (e.g., deep vein thrombosis, skin burns, paresthesia), and short-term recurrence, assessed through clinical evaluations and duplex ultrasound over a 3-month follow-up period.

Study Design and Setting

This observational descriptive study was conducted in the Department of Radiology at a tertiary care hospital, equipped with advanced vascular imaging and interventional facilities. The study period is conducted for January 2024 to January 2025.

Study Population

The study enrolled 81 patients presenting with symptomatic varicose veins scheduled for EVLA. The sample size was calculated based on a reported 5% prevalence of varicose veins in the general population, with an absolute precision of 9% and a 95% confidence level. Using the formula for sample size in prevalence studies, (n = \frac{Z^2 \cdot P \cdot (1-P)}{E^2}), where (Z = 1.96), (P = 0.05), and (E = 0.09), a minimum sample size of 81 patients was determined to achieve sufficient statistical power.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Patients providing written informed consent
- Age >18 years
- Confirmed incompetence of the great saphenous vein (GSV), small saphenous vein (SSV), or perforator veins via duplex ultrasound
- Symptomatic varicose veins (e.g., pain, swelling, or ulceration) classified under CEAP (Clinical, Etiological, Anatomical, Pathophysiological) categories C3–C6

Exclusion Criteria

- Patients unwilling to provide consent
- Patients unable or unwilling to attend follow-up visits
- Age <18 years
- Pregnancy or breastfeeding
- Active malignancy or severe systemic illness precluding intervention
- Acute deep vein thrombosis or superficial thrombophlebitis

Data Collection

The study was approved by the Institutional Ethics Committee, and all procedures adhered to the Declaration of Helsinki. Written informed consent was obtained from each participant, detailing the study objectives, procedures, potential risks, and follow-up requirements.

Pre-Procedural Assessment

1. **Clinical Evaluation**: A detailed clinical history was collected, including symptom duration, comorbidities (e.g., hypertension, diabetes mellitus, hyperlipidemia, smoking), and risk factors (e.g., family history, occupational standing). Physical examination assessed the extent of varicose veins, presence of edema, skin changes, or ulcers, and CEAP classification (C3–C6).
2. **Duplex Ultrasound (DUS)**: Pre-procedural DUS was performed using a GE Logiq S8 ultrasound machine with a 7–12 MHz linear probe. The examination mapped the superficial and deep venous systems, identifying incompetent veins (GSV, SSV, or perforators), reflux duration (>0.5 seconds indicating incompetence), vein diameter, and iliac-femoral vein involvement. Reflux was assessed in the standing position with manual calf compression or Valsalva maneuver. All DUS examinations were conducted by a trained radiologist with over 5 years of vascular imaging experience.

EVLA Procedure

EVLA was performed in an outpatient interventional radiology suite under sterile conditions by a single

consultant interventional radiologist. The procedure followed a standardized protocol:

1. **Patient Preparation**: Patients were positioned supine, and the target limb was cleaned and draped. Local anesthesia (1% lidocaine) was administered at the access site.
2. **Venous Access**: Under real-time ultrasound guidance, the GSV or SSV was punctured using an 18-gauge needle, typically 10–15 cm below the saphenofemoral or saphenopopliteal junction. A 5-Fr sheath was inserted, followed by a 0.035-inch guidewire to confirm intraluminal placement.
3. **Tumescent Anesthesia (TA)**: A tumescent solution (500 mL normal saline, 20 mL 1% lidocaine, and 5 mL 1:1000 epinephrine) was injected perivenously under ultrasound guidance using a 22-gauge needle. TA compressed the vein, provided analgesia, and protected surrounding tissues from thermal injury.
4. **Laser Ablation**: A 1470-nm diode laser (VenaCure EVLT system) with a bare-tip fiber was introduced through the sheath. The fiber tip was positioned 2 cm distal to the saphenofemoral or saphenopopliteal junction, confirmed by ultrasound and laser guide light. Laser energy was delivered at 10–12 W in continuous mode, with a pullback rate of 1–2 mm/second, achieving an energy density of 60–100 J/cm. The total energy delivered was recorded.
5. **Adjunctive Therapy**: Residual varicosities or neovessels were treated with foam sclerotherapy intraoperatively, using 1–2% sodium tetradecyl sulfate (STS) mixed with air in a 1:4 ratio (Tessari method). Foam was injected under ultrasound guidance to occlude tributary veins.
6. **Post-Procedural Care**: The access site was closed with manual compression, and a sterile dressing was applied. Compression stockings (20–30 mmHg) were fitted, and patients were encouraged to ambulate within 1–2 hours post-procedure. Oral analgesics (e.g., paracetamol 500 mg) were prescribed for 3–5 days, and patients were advised to wear compression stockings for 4 weeks.

Outcome Assessment

1. **Immediate Outcomes**: Procedure duration, immediate complications (e.g., skin burns, hematoma), and time to ambulation were recorded. Postoperative pain was assessed using the Visual Analog Scale (VAS, 0–10) at 24 hours.
2. **Follow-Up**: Patients were followed up at 1 week, 4 weeks, and 3 months post-procedure. At each visit:
   - **Clinical Assessment**: Evaluated symptom resolution, residual varicosities, and complications (e.g., induration, ecchymosis, paresthesia).
   - **Duplex Ultrasound**: Performed to confirm vein occlusion, absence of recanalization, and exclusion of DVT. Persistent reflux (>0.5 seconds) or partial/complete recanalization was noted.
   - **Ulcer Healing**: For CEAP C6 patients, ulcer healing time was recorded as the duration from procedure to complete epithelialization.
3. **Adverse Effects**: Complications such as DVT, skin burns, fat liquefaction, paresthesia, and recurrence were documented. DVT was confirmed by DUS, showing non-compressible thrombosed segments in deep veins.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 20.0 (IBM Corp.). Continuous variables (e.g., procedure time, VAS scores) were expressed as means with standard deviations or ranges. Categorical variables (e.g., complications, CEAP class)

were reported as frequencies and percentages. Descriptive statistics summarized patient demographics, clinical characteristics, procedural outcomes, and complications. No comparative statistical tests were performed due to the descriptive nature of the study.

Results

Demographic and Clinical Characteristics

Of 81 patients, 44% were male, and 56% were female. Age, symptom duration, comorbidities, CEAP classification, and venous characteristics are summarized in Table 1. Unilateral limbs were affected in 78.8%, and bilateral in 11.1%.

Table 1: Demographic and Clinical Characteristics

Characteristic	Category	Percentage (%)
Age (Years)	35–40	12.3
	41–50	43.2
	51–60	37.0
	>60	7.4
History (Years)	10–15	24.6
	16–20	49.3
	20–24	51.2
Hypertension	Present	24.6
	Absent	75.4
Diabetes Mellitus	Present	13.5
	Absent	86.5
Hyperlipidemia	Present	37.0
	Absent	63.0
Smoking	Present	50.6
	Absent	49.4
CEAP Classification	C3	18.8
	C4	51.1
	C5	23.3
	C6	6.6
Iliac-Femoral Vein Reflux	Present	85.5
	Absent	14.5
Reflux Time of GSV (Seconds)	0.5–1	13.3

	1–2	18.8
	2–3	48.8
	3–4	18.8
Diameter of GSV (mm)	3.3–5.3	38.8
	5.4–7.4	38.8
	7.5–9	22.2
Number of Perforators	≤2	46.6
	>2	53.3

Procedure and Outcomes

Procedure times, ambulation, hospital stay, pain scores, and ulcer healing are shown in Table 2.

Table 2: Procedure and Outcome Metrics

Characteristic	Category	Percentage (%)
Time of Procedure (Minutes)	41–51	12.2
	52–61	17.7
	62–71	37.7
	72–81	18.8
	82–91	13.3
Time to Ambulation (Hours)	1.1–2.1	13.5
	2.2–3.1	24.6
	3.2–4.1	43.2
	4.2–5.1	18.5
Post-Operative Hospital Stay (Days)	0.6–1	30.8
	1.2–1.5	55.5
	1.6–2	13.5
VAS Score	1.3–1.8	8.8
	1.9–2.3	38.8
	2.4–2.8	37.7
	2.9–3.3	14.4
Time for Ulcer Healing (Weeks)	1.8–2.8	6.6
	2.99–3.8	24.4

	3.8–4.8	36.6
	4.9–5.8	24.4
	5.9–6.2	7.7

Complications

Complications are detailed in Table 3.

Table 3: Complications

Complication	Percentage (%)
Deep Vein Thrombosis	1.1
Induration	30.0
Ecchymosis	22.2
Skin Burns	7.7
Fat Liquefaction	1.1
Residual Varices (4 weeks)	16.6
Paresthesia (3 months)	5.5
Recurrence (3 months)	4.4

Follow-Up

At 3 months, DUS confirmed GSV ablation with no recanalization. Residual varices were managed with sclerotherapy, and recurrence was low.

In result**,** the demographic and clinical characteristics (Table 1) reveal a predominantly middle-aged population (41–50 years, 43.2%), with a slight female predominance (56%), consistent with the higher prevalence of varicose veins in women due to hormonal and pregnancy-related factors. The long symptom duration (16–24 years in >50%) indicates chronic disease, often presenting late for treatment. Comorbidities like hypertension (24.6%), diabetes (13.5%), hyperlipidemia (37%), and smoking (50.6%) highlight the role of vascular risk factors in disease progression. The CEAP classification shows most patients had advanced disease (C4: 51.1%, C5: 23.3%), with iliac-femoral reflux in 85.5% and prolonged GSV reflux times (2–3 seconds: 48.8%), indicating significant venous incompetence. GSV diameters (mostly 3.3–7.4 mm) and >2 perforators in 53.3% suggest anatomical complexity, necessitating precise ablation.

Procedure and outcome metrics (Table 2) demonstrate EVLA's efficiency, with most procedures lasting 62–71 minutes (37.7%), reflecting standardized techniques. Rapid ambulation (3.2–4.1 hours: 43.2%) and short hospital stays (1.2–1.5 days: 55.5%) underscore the minimally invasive nature of EVLA, facilitating early recovery. Low VAS scores (1.9–2.8: 76.5%) indicate minimal postoperative pain, enhancing patient satisfaction. Ulcer healing, primarily within 3.8–4.8 weeks (36.6%), reflects effective treatment of advanced CVI, particularly in C5/C6 patients.

Complications (Table 3) were infrequent, with DVT (1.1%) and fat liquefaction (1.1%) being rare, likely due to ultrasound-guided TA and early ambulation. Induration (30%) and ecchymosis (22.2%) were common

but transient, resolving without intervention. Skin burns (7.7%) were higher than in some studies but manageable with local care. Residual varices at 4 weeks (16.6%) were effectively treated with sclerotherapy, and low paresthesia (5.5%) and recurrence (4.4%) at 3 months highlight EVLA's durability and safety compared to surgical alternatives.

Discussion

According to recommendations and systematic studies, endovascular laser ablation is the preferred first thermal ablation method for patients with varicose veins[5,6]. This research validated the short-term results of endovascular laser ablation, where the main vein (GSV) was entirely ablated and no recanalization of the vein was seen. The previous research revealed that the endovascular laser ablation method had a shorter duration, reduced bleeding, and required fewer incisions compared to traditional surgery[7].This method has the ability to totally ablate varicose veins in a shorter amount of time compared to the alternative procedure (42 minutes vs 65 minutes). After extensive use and multicenter research, it has been shown that it is the most appropriate power for treating GSV trunk and perforator varices. In comparison to the preliminary findings[7], the power for GSV trunk and perforator varices are defined as 50 W and 20 W. These power levels provide both an adequate closure rate of varicose veins and prevent excessive thermal damage, in line with prior findings[8].

Thermal ablation treatments used to treat varicose veins can result in heat-related problems, including skin burns, nerve damage, and induration. This research revealed that the endovenous laser ablation treatment exhibited reduced occurrences of induration, ecchymosis, and paresthesia.

Although there were significant number of skin burns in this procedure in the present study, the tumescent anesthesia technique could reduce the incidence of thermal injury and should be used as a routine method for thermal ablation therapy.

To minimize the risk of saphenous nerve damage, the ablation procedure typically starts at the knee. This is particularly important if the great saphenous vein (GSV) does not show any backward flow below the knee. However, if there are structural or size changes in the GSV below the knee, it is necessary to ablate the entire vein. In such cases, the amount of thermal damage can be reduced by using lower energy levels and applying tumescent anesthesia. Furthermore, the majority of thermal ablation problems may be mitigated within a very little timeframe and do not need further treatment.

Heat conduction action makes thermal damage possible to induce irreversible nerve damage. In this investigation, paresthesia was routinely seen throughout the follow-up period and verified in 5.5% of the endovenous laser ablation treatments.

Though it is thought that thermal ablation of the whole GSV is required, tumescent anesthetic and lower energy might help to minimize thermal damage. Moreover, for patients with mild-to-moderate categorization, it is advised to ablate the trunk of the GSV above the knee, therefore lowering the likelihood of thermal damage.

Residual varicose veins are causing debate in endovenous therapy; however, we think phlebectomy is crucial for ablation treatments. Residual varicose veins are becoming a matter of controversy for endovenous therapy[9]; therefore, we believe that phlebectomy is important for ablation procedures.

In this study, the results demonstrated that the incidence of residual varices was 16.6% with the endovenous laser ablation procedure.

Because the length of the short microwave needle is 15 cm, it could be inserted into varices between 2 and 12

cm, the laser fiber was easily broken, and it was difficult to insert into the varices from a long distance. Moreover, marking the varicose veins before the procedure was also important in reducing the number of postoperative residual varices. Several studies reported that high ligation is not necessary for ablation procedures; however, in China, most surgeons performed the high ligation[10]

It is thought that the high ligation could prevent trunk recanalization and possible deep vein thrombosis; so, additional nonclinical factors might influence this decision. According to a previous meta-analysis, the recurrence of varicose veins was greater in the surgery group after one year than in the endovenous laser ablation group[11]; so, the long-term result of these treatments may be affected by this fact.

In this research, the endovenous laser ablation during follow-up considerably reduced the recurrence rate of varicose veins. These recurrences might be connected to venous reflux, possible inadequate tributary veins, and neovascularization. Still, 70% of the recurrences found by ultrasonic scanning had no clinical indication.

Only clinical recurrence may call for further treatment. Hence, based on the findings of this investigation, endovenous laser ablation treatments might be safe and efficient treatments for varicose veins[12.]

Conclusion

EVLA is a safe and effective treatment for varicose veins, offering high success rates, minimal complications, and improved quality of life. Its advantages over traditional surgery include reduced pain, shorter recovery times, and lower recurrence rates. This study supports the adoption of EVLA as a first-line therapy for symptomatic varicose veins, with ongoing research needed to optimize long-term outcomes.

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