Endovenous Laser Treatment for Varicose Veins in Patients with Active Ulcers: Measurement of Intravenous and Perivenous Temperatures during the Procedure

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BACKGROUND Conventional saphenous vein stripping is difficult to be indicated for the treatment of varicose veins in patients classified as CEAP C4, C5, or C6.

OBJECTIVE This study was developed to evaluate treatment results for varicose veins with active ulcers using endovenous laser (EVL), compared to a group undergoing clinical treatment, during 1 year.

PATIENTS AND METHOD Fifty-two patients presenting with varicose veins with active ulcers for more than 1 year were divided for treatment into two randomized groups: Group 1, clinical treatment, composed of 25 subjects, was submitted to elastic or inelastic compression therapy; Group 2, EVL treatment, composed of 27 subjects, was submitted to great and or small saphenous vein ablation with a 980-nm diode EVL, plus the clinical treatment. Intravenous and perivenous temperatures were measured continuously during the EVL treatment. All patients were followed for 12 months and studied with ultrasound at the beginning and end of the study. The ulcers' areas were evaluated initially and at every 3 months.

RESULTS In 12 months, 81.5% of the wounds in patients in Group 2 and only 24% in patients in Group 1 had healed. Ulcer recurrence rate was 44.4% in Group 1. The mean wound area in Group 1 decreased from 17.48 to 12.76 cm^2 at the end of the year. In Group 2, the wound area decreased from 22.26 to 2.7 cm^2 ($p = .0037$). Mean intravenous and perivenous temperatures of 79.3 and 43.0°C were recorded.

CONCLUSION The treatment for varicose veins with EVL is safe in patients with active ulcers. Wounds healed faster than in patients undergoing clinical treatment alone during a 1-year period. There was no ulcer recurrence in patients treated with EVL.

The authors have indicated no significant interest with commercial supporters.

Knowledge of varicose veins in the lower limbs is ancient and was engraved on stone in a Greek temple dating back to 3000 B.C.[1] Nevertheless, attempts at treatment only appeared more recently by the end of the 18th century until the present. The best results were obtained with stripping of the dilated veins, using the technique recommended by Babcock in 1907 and is still currently accepted by the medical literature.[2] Since that time, no major technical advance has been recorded in the area of varicose vein surgery, which is performed essentially with the same technique as it was in the past 100 years.

The concept of provoking heat inside a dilated vein using laser, named endovenous laser (EVL), to produce photothermal sclerosis was formulated by Boné in 1998. The first record dates from 1999.[3] Such study allowed the publication of other important articles showing good results and few complications, arousing interest in the medical class for this minimally invasive treatment of varicose veins.[4–10]

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In more advanced stages of chronic venous insufficiency with clinical classifications CEAP C4, C5, and C6, the limitations or contraindications to surgical treatment by conventional vein stripping are due to areas of extensive dermatosclerosis, fibrosis, ulcer scarring sequelae, active ulcers, edema, and lymphedema.[11]

This study was developed to prospectively evaluate treatment results of EVL use for management of varicose vein with active ulcers, compared to another group of varicose vein patients who also had active ulcers and were undergoing clinical treatment during a 1-year period.

Patients and Methods

Fifty-two consecutive patients with varicose veins in the lower limbs with active ulcers were selected. Varicose veins were categorized as primary, and patients had been undergoing treatment in the Vascular Surgery Outpatient Facility at the Clinics Hospital of the Universidade Estadual de Campinas (UNICAMP) for more than 1 year.

Exclusion criteria were patients who had previously undergone saphenectomy; those with acute deep venous thrombosis or superficial thrombophlebitis, occlusion of the femoral or iliac vein presenting with postthrombotic syndrome, coagulation disorders, peripheral arterial disease, or degenerative systemic diseases; pregnant women; and those who were unable to ambulate.

For each patient studied, a summary of the general clinical history, ulcerating lesions evolution (duration in years, recurrences, and types of treatments performed), and other comorbidities (diabetes, arterial hypertension, heart, lung, and kidney disease) was recorded. The basic characteristics of patients were similar in both groups and are shown in Table 1.

All patients were evaluated with duplex ultrasound (ATL HDI 3000, Advanced Technology Laboratories, Redmond, WA) with broadband linear array transducer (5–12 MHz) and had important reflux at the great saphenous vein (GSV), small saphenous vein (SSV), or both. In addition, all patients presented a mean of 1.6 incompetent perforators near or in the site of the ulcer and other important branches with reflux.

TABLE 1. Patient Characteristics

Characteristic	*Group 1*	*Group 2*	p *Value*
Mean age (years)	60.7	57.4	.4147
Female/male sex	18/7	21/6	
CEAP classification	All C6	All C6	
Mean ulcer area (cm^2)	17.48	22.26	.5355

This study was approved by the Research Ethics Committee of the Medical School of the State University of Campinas (UNICAMP), under No. 039/2005. The patients previously signed an informed consent form and the study protocol conformed to the 1975 Declaration of Helsinki. All patients were offered the clinical treatment. Two groups of patients randomly allocated (case yes/case no) to receive clinical treatment or EVL plus clinical treatment were studied: Group 1, composed of 25 patients with follow-up for clinical treatment; and Group 2, composed of 27 patients treated with EVL plus clinical treatment.

The clinical treatment proposed to the patients consisted in applying dressings at home, followed by the use of an elastic support (hose or an elastic bandage) or an Unna's boot, according to medical recommendation. No special care or advice was given to any patient in Group 1.

Patients in Group 2 underwent EVL treatment for trunk varicose veins and major branches with reflux, always by the same surgeon. The GSV was treated in 17 cases (63.0%), the SSV in 3 cases (11.1%), and both saphenous veins in 7 cases (25.9%). The Giacomini vein was treated in 3 cases. After 48 hours of compression bandages (20–30 mmHg) all surgical patients continued to apply dressings at home following the routine adopted in the preoperative

period, in a manner similar to that of the patients in Group 1.

Patient follow-up lasted 1 year. Ultrasound control was performed after 1 week and 30 days and every 3 months until completing 12 months after intervention (Group 2) and in the beginning and at the closing of the study in Group 1. Measurements of ulcer areas were made at the beginning and at 30 days and every 3 months, in both groups. Ulcer areas were measured by placing a plastic transparent sheet over the ulcer and tracing the wound area with a pen. Afterward, a digital photograph of this map was made along a metric scale. The photographs were transferred to a computer where the area was calculated in square centimeters with the aid of computer software (DicomWorks v 1.3.5, Philippe Puech and Loïc Boissel, 2001).

Technique of EVL Treatment

The device used was a 980-nm-wavelength diode laser, optic power of 15 W, and pulse-mode operation (Biolitec, Biomedical Technology, Bonn, Germany). Immediately before treatment, the patients were mapped with ultrasound Mode-B, standing up, to determine the diameter of the vein to be treated. Vein diameter was written on the limb at 10 cm intervals starting at the saphenofemoral junction. The amount of energy necessary to obliterate the vein was empirically determined by the authors, based on previous experience, to be 80 J per linear centimeter. To obtain this, the pulse energy was set to 3 J/mm vein diameter and the pulses were repeated in each 1-cm segment to achieve a minimum of 80 J. For example, for an 8-mm GSV, the pulses were set to 24 J and four pulses were applied for each linear centimeter of the vein. All patients received 15 mg midazolam by the oral route, 30 minutes before the procedure.

Vein access for endoluminal placement of the fibers was achieved by means of percutaneous venipuncture under ultrasound guidance, using a 16-gauge needle at the ankle or the knee levels. A 600-μm fiber optic was introduced directly into the vein, placing its tip immediately distal to insertion of the superficial epigastric vein at the groin. When the puncture was made in the knee level, the optic fiber was introduced proximally and distally to treat the entire length of the GSV. Local anesthesia using tumescent infiltration with 50 to 200 mL of 0.2% lidocaine was also performed under ultrasound guidance.

The laser energy, previously calculated for each site, was delivered in pulse mode. The fiber was manually retracted 2- to 5-mm at intervals between pulses. The resting period was gauged to 2 seconds. This cycle was repeated until a distance of 1.0 cm from the puncture site. In all cases, the GSV and/or SSV has been treated from the groin to the ankle. Subsequently, the fiber was removed and the more important collaterals received EVL therapy through multiple punctures. Because there was no means of maintaining a continuous traction on the optic fiber, it was decided to treat all patients by means of pulsed mode laser only. With the completion of laser intervention, patients received a Class II elastic compression (20–30 mmHg) that was applied to the entire extent of their limbs. The patients were instructed to wait in a supine position with their legs elevated until they were in optimal condition to ambulate. Discharge from the post anesthesia recovery room occurred 2 to 3 hours later. An elastic band was used for 2 consecutive days, and routine preoperative therapy was resumed afterward.

In all patients treated with EVL, benzathine penicillin (1,200,000 U intramuscularly in a single dosage) and 500 mg cephalexin every 6 hours were administered for 1 week. During and after the procedure, the patients were inquired about pain and responded to only three alternatives: no pain, bearable pain, and unbearable pain.

Measurement of Intravenous and Perivenous Temperature

During each procedure, intravenous and perivenous temperatures were measured continuously, at the same height of the vein (in real treatment situation)

TABLE 2. Rate of Ulcers Healed

		Follow-up time (months)			
Group	*Number*	*3*	*6*	*9*	*12*
1	25	3 (12.0%)	5 (20.0%)	4 (16.0%)	6 (24%)
2	27	17 (62.9%)	22 (81.5%)	22 (81.5%)	22 (81.5%)

$p < .05$

during traction of the optic fiber, for all times of treatment. The study site chosen for the GSV was the middle thigh or middle leg region. For the SSV, the site chosen was the middle leg region. Measurements were made once for each patient. The introduction of a probe (thermocouple) into the vein, for temperature measurement, was performed by venipuncture with a 14-gauge needle. Another probe was placed perivenously, 4 mm (SD, 1 mm) near the vein wall. Both punctures were guided by ultrasound.

The probes for temperature readings (intravascular and perivascular) were connected to a digital thermometer (TESTO 175, Testo, Inc., Lenzkirch, Germany) with a serial interface allowing connection to a microcomputer. Using the bundled software, temperature readings were made and recorded every 2.0 seconds in both channels in real time, during all the treatment, allowing the correlation between temperature levels achieved and the amount of energy delivered.

Statistical Analysis

The category variables were shown in contingency tables, containing absolute and relative values. The numerical values were analyzed by descriptive statistics. Analysis of differences between both groups was performed with Student's *t*-test for independent samples and chi-square test. Statistical significance was set at $p < .05$.

Results

At the end of the third month of treatment, 17 of 27 patients treated with laser had their ulcers completely healed (62.9%), whereas in the clinical treatment group, only 3 (12.0%) of 25 patients had complete wound healing ($p = .0002$). At the end of the first year of study, ulcers healed completely in 81.5% of the patients treated with laser, whereas complete healing occurred in only 24% of those in the clinical treatment group ($p = .0001$; Table 2). The clinical course of the mean ulcer area in both groups is demonstrated in Table 3. Among patients in Group 1, of 9 limbs (36%) that had healed, 4 (44.4%) presented with ulcer recurrence within 30 to 90 days after healing. Of these, only 1 limb (25%) healed again (Table 4).

Measurements of intravenous temperatures were taken during the procedures, oscillating between a

TABLE 3. Clinical Course of the Mean Ulcer Area in Both Groups

	Ulcer area (cm^2)		
	Group 1 (clinical) n = *25*	*Group 2 (laser)* n = *27*	p *Value* ($\alpha = 0.05$)
Start	17.48	22.26	.5355
3 months	16.9	5.70	.0154
6 months	14.72	2.85	.0033
9 months	12.12	2.70	.0022
12 months	12.76	2.70	.0037

TABLE 4. Comparative Rate of Ulcer Healed and Ulcer Recurrence

Group	*Number*	*Total number of ulcers healed during the study (%)*	*Recurrence of ulcers in relation to the healed total (%)*	*Total number of ulcers healed at the end of the study (%)*
1	25	9 (36,0%)	4 (44.4%)	6 (24.0%)
2	27	22 (81,5%)	0	22 (81.5%)

minimum of 61.1°C and maximum of 96.3°C (mean, 79.3°C; SD, 12.44°C). Perivenous temperature oscillated between a minimum of 35.5°C and maximum of 48.4°C (mean, 43.0°C; SD, 5.28°C). In all cases, immediate venous occlusion was a constant factor that did not change during ultrasound controls until the end of the study.

The mean length of treated vein was of 51.7 cm for the GSV and 32.0 cm for the SSV (including the Giacomini vein). The mean amount of laser energy delivered was of 95.17 J/cm in GSV (SD, 19.9 J/cm) and 88.7 J/cm in the SSV (SD, 25.1 J/cm).

Adverse Effects

The procedure was performed under local anesthesia using tumescent infiltration and was very well tolerated by the majority of the patients. In 9 limbs treated (33.3%), however, the patients complained of "bearable" pain, which did not prevent or make it difficult to continue the procedure. No case of "unbearable" pain was found. Ecchymoses were observed in 17 limbs (62.9%), in the length of the GSV, and were more extensive along the middle and distal one-third of the thigh, completely disappearing with no sequelae at the end of the 4th week. Induration of the vein undergoing treatment was observed in 18.5% of cases (5 limbs). There were no cases of phlebitis, deep vein thrombosis, or pulmonary embolism. In 1 limb (3.7%), hyperpigmentation occurred in the length of the GSV. Transient paresthesia was observed in 6 limbs (22.2%), located in the medial surface of the middle and distal one-third of the leg and medial and/or lateral inframalleolus region. All cases had complete spontaneous remission at the end of the 6th month, without need of any further treatment. No case of infection related to the procedure was found. In 1 limb (3.7%), there was a skin burn in the medial surface of the middle one-third of the leg, forming a bleb and ulcer, which resolved completely by the end of the 3rd month, resulting in small scarring sequelae. There was also one case (3.7%) of lipoid necrosis in the medial surface of the upper one-third of the leg in which ultrasound-guided aspiration became necessary in the 10th day, with complete resolution at the end of the first month and no sequelae. In two cases (7.4%), thrombus extended 2 or 3 mm from the internal saphenous vein to the common femoral vein, without progression; no deep vein thrombosis or pulmonary embolism was observed and complete spontaneous resolution occurred by the end of the 1st month. All patients were satisfied with the decision to undergo EVL treatment and the subsequent results.

Discussion

The protocol employed in this study was modified and adapted from the studies by Navarro and colleagues[12] among others.[13,14] The performance of conventional varicose vein surgery for patients with varicose ulcers may not always be indicated due to risks from infection and unsuitability of the skin overlying the region to be treated. Furthermore, anesthesia is required and these patients who have common comorbid conditions (obesity, diabetes, and advanced age) are bedridden for a certain period of time after surgery causing serious inconvenience.[14–16] If the region to be treated has infected wounds and fibrosis, the surgeon is unable to remove the veins adequately, especially in the distal leg region.

The correction of venous reflux as proposed by EVL use, with immediate permission to ambulate, seems to be the most adequate course of action. All effort should be made to reestablish normal hemodynamic conditions in the limb and the social life of each patient.

Ultrasound study at 1 week and 30 days after EVL treatment always showed obstruction of the veins treated. There were very few sites of blood pooling and absence of circulation. Complications found within 30 days were hyperpigmentation, fibrosis in the length of the vein, and regional ecchymosis and no case required treatment. There was no case of deep vein thrombosis or symptomatic pulmonary embolism. No case of worsening of ulcer infection was found. In contrast, improvement of local infection and secretions was noted.

All patients treated with EVL showed improvement within 30 days, either by a decrease in the size of the ulcers (Table 3) or by a reduction in the severity of edema in the distal leg region, which patients referred to as "the treated leg being the lighter leg for walking." In addition, the ulcers became shallower and with less secretions. Changes in wound color from yellowish to reddish and no pain in some cases were observed.

Ulcer closure occurred in 3 months in 62.9% (17 limbs) and in 30 days (44.4%) in 12 cases. Ulcer areas smaller than 5 cm^2 had the best response in 90 days. Age appeared not to have influence on ulcer healing because one 88-year-old patient recovered quickly after treatment. Patients who delayed in responding with complete healing had complete tibial tarsal ankylosis with atrophic calf muscle. In these cases, gait disturbance could be responsible for maintaining residual edema, although it was milder than before surgery. These patients were advised to wear knee-length elastic stockings on a permanent basis.

No major complication could be attributed to the technique proposed. It could now be considered the optimal treatment for CEAP-C6 patients in the manner proposed. Whether laser can be used for varicose veins without complications and in young patients is debatable, because of the low complication rates currently seen with vein stripping. Lesion of the saphenous nerve is the most feared complication.[17]

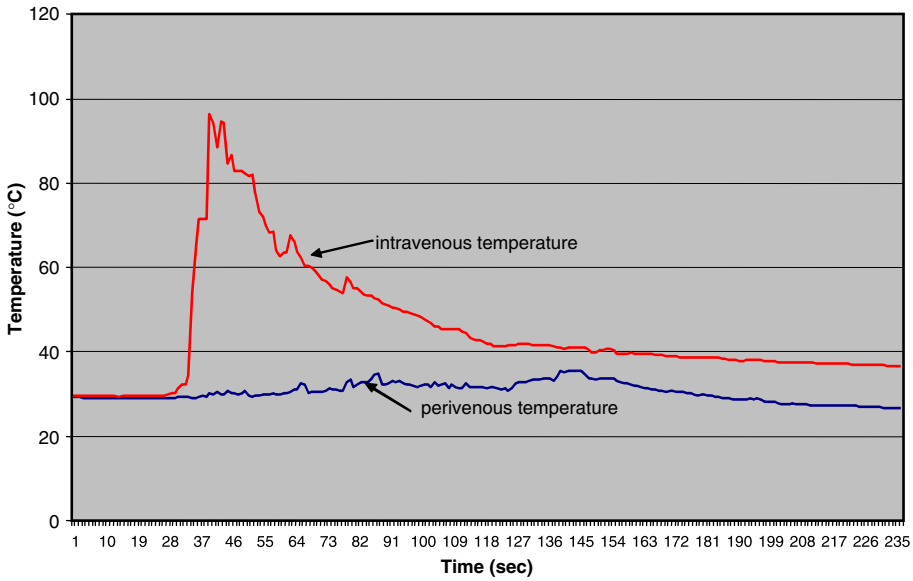

Figure 1. Intravenous and perivenous temperature during endovenous treatment of varicose veins.

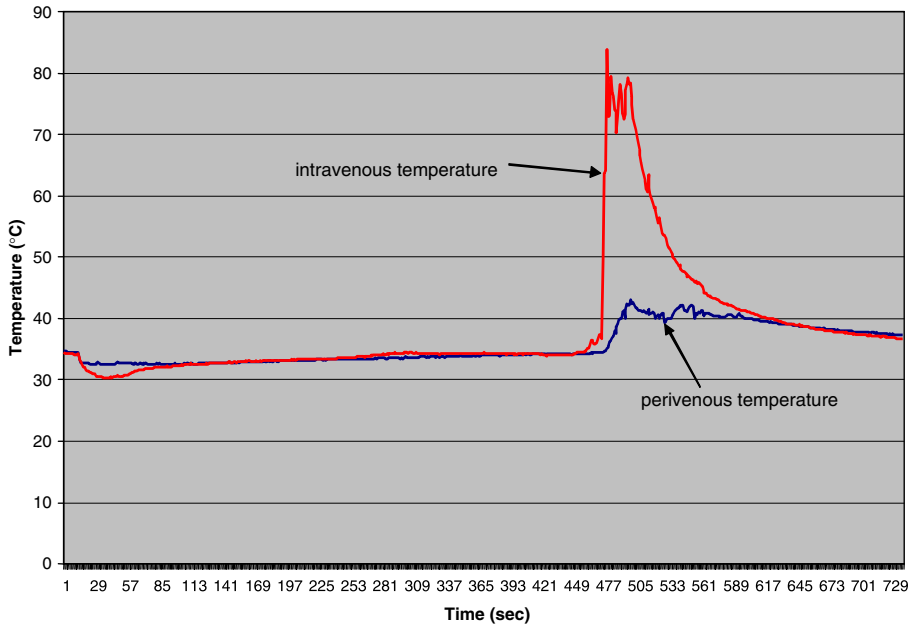

Figure 2. Intravenous and perivenous temperature during endovenous laser treatment for varicose veins.

The thermometer used was considered optimal, comfortable, and safe for the patient. It also came bundled with an extremely versatile and reliable program. A temperature study showed that inside the vein the temperature achieved was variable, although the same technique (laser power calculation) and instrument were used. This variation is still the object of ongoing investigation. Mean temperature was 79.3°C, ranging from 61.1 to 96.3°C at the time the fiber reached the thermometer. In all cases, retraction and immediate occlusion of the vein were observed. There was no difference between immediate and late occlusion rates. No treatment failure or vein recanalization occurred during the study period.

Temperature measurements taken in real treatment situation allowed us to observe the efficiency in thermal protection. Protection was provided by perivascular tumescent infiltration that was correctly performed under ultrasound guidance, maintaining mean perivenous temperatures consistently below 45°C. Meanwhile, mean intravenous temperatures were maintained above 75°C. These thermal curve characteristics ensure efficiency in treatment with a low complication rate.[18,19]

External temperatures were much lower (between 45 and 50°C), lasted a much shorter period, and showed adjustment for power calculation. An important observation was that peak intravenous temperature was of a short duration, but the temperature inside the vessel was maintained above 50°C for more than 2 minutes (ranging from 120 to 240 seconds; (Figures 1 and 2) after laser pulse was delivered. This may be a factor determining the definitive thermal lesion in the vessel wall.[18,19]

Because varicose vein recurrence is always a possibility, these patients should be evaluated annually (duplex Doppler ultrasound). The procedures must be repeated whenever new branches that are considered important appear and venous reflux occurs.

In conclusion, the technique proposed should be used for these cases in the modern medical armamentarium because it is capable of correcting superficial venous reflux in a "minimally invasive" and definitive manner, in the more difficult patients.

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COMMENTARY

This is a very good paper, describing a well-done study on a very important topic. This is the only paper of which I am aware that examines the direct correlation between thermoablation of the incompetent great saphenous vein (GSV) and ulcer healing in C6 patients only, compared to traditional "medical" care. I do have a few comments. First, the rate of paresthesia following laser ablation of the GSV is quite high at 22%, even though it is apparently short-lived. I also noticed that patients complained of "bearable pain" during the procedure. Both of these factors indicate less than adequate perivenous local anesthesia, and as the authors gain experience, the rate of paresthesia should diminish dramatically. Furthermore, either adequate local anesthesia to protect the saphenous nerve or limiting treatment to the portion of GSV above the knee should also improve the paresthesia rate. I suspect that the paresthesia rate for those patients treated along the entire length of the GSV is much higher than for those treated above the knee only. Second, I am unclear from the authors' description how these patients were randomized to surgical versus medical care and if there may have been any bias introduced at that step. Third, I am curious how close the perivenous temperature probe was to the vein and how this distance was determined and

therefore where these perivenous temperatures were monitored. This measurement could also explain a 22% paresthesia rate if it was more monitored than 1 to 2 mm from the vein. This information is more important to me as a clinician than a description of the exact nature of the temperature-measuring equipment and software that was used. Fourth, the quality of the ultrasound equipment and the sensitivity of the transducer has a direct correlation with the ability to achieve accurate failure rates. These are not specified in the study, and I question a 100% success rate, even at 1 year. Fifth, it appears that the only adjuvant therapy in the surgical patients was laser ablation of some tributary veins. I think with carefully conducted follow-up duplex exams, and ultrasound-guided sclerotherapy directed to the other sources of reflux, such as perforators, in the area of the ulcers, the authors might well have achieved an even higher rate of successful, "permanent" healing of the ulcers. Finally, the medical care that Group 1 received for the venous ulcers, while probably typical in a nonspecialized setting, was abysmal, apparently consisting of bandages, elastic wraps, and the occasional Unna's boot. Surely a much higher healing rate could have been achieved with inelastic dressings (other than Unna's boot), compression hose, and careful, knowledgeable follow up. In all fairness, it appears that the patients in Group 2, after 48 hours of compression hose, may have received the same sort of inadequate medical care.

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