Tumescence Anesthesia Solution–Assisted Laser Ablation Treatment of Lower Limb Varicose Veins: The Effect of Temperature of the Tumescence Anesthesia Solution on Intraoperative and Postoperative Pain, Clinical Observations, and Comprehensive Nursing Care

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Purpose: *To investigate the effect of cold and room temperature tumescence anesthesia solution (TAS) on the treatment of lower limb varicose veins via endovenous laser ablation.*
Design: *On the basis of the TAS temperature, patients were divided into two groups: group A (n = 26) received room temperature (24°C) TAS, and group B (n = 25) received cold (4°C) TAS.*
Methods: *A numerical rating scale was used to evaluate pain. Perioperative and intraoperative nursing care and clinical observations were performed following a generalized standard.*
Findings: *Percentages of patients who felt pain in groups A and B were 69.2% and 36.0%. Average numerical rating scale scores of patients in the two groups (A and B) on the day of surgery and on postoperative days 1, 2, and 3 were 4.3 versus 2.1, 3.5 versus 1.0, 3.0 versus 0.8, and 1.6 versus 0.3, respectively.*
Conclusions: *Cold TAS reduces intraoperative and postoperative pain more effectively than room temperature.*

Keywords: *tumescence anesthesia solution, endovenous laser ablation, lower limb varicose veins, nursing, temperature, pain.*

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LOWER LIMB VARICOSE VEINS represent a common chronic peripheral vascular disease. Its incidence rate is up to 20% to 30%, and its incidence in women is higher than that in men.[1] Patients with this condition often feel swelling, fatigue, and heaviness of the ipsilateral limb. Because of the nutritional disorders of the ankle skin, the skin of the ipsilateral limb is prone to eczema, dermatitis, superficial phlebitis, pigmentation, and even ulcers, which can severely and negatively affect patients' lives.[2] Many methods exist to treat lower limb varicose veins, including the high ligation of the greater saphenous vein, the stripping of the greater saphenous vein, ultrasound-guided sclerotherapy, and joint therapy using multiple methods.[3,4] Previously, surgery was the most radical method for lower limb varicose veins. Because of numerous untreated collateral vessels, the efficacy of simple high ligation of the greater saphenous vein was not positive. Although the stripping of the greater saphenous vein showed strong efficacy, the trauma was significant.[5]

With the development of medical technology, laser ablation and radiofrequency ablation have replaced traditional open surgery for lower limb varicose veins.[6] Of these options, laser ablation is more frequently used. Recently, endovenous laser ablation (EVLA) has achieved important progress in the treatment of superficial lower limb varicose veins. Furthermore, the efficacy of EVLA is equivalent to surgical stripping treatment; importantly, however, it reduces adverse responses and recovery time while improving quality of life.[7] The mechanism of this technique is based on heat damage to the vascular endothelium; as such, intraoperative pain is often obvious.

The use of tumescence anesthesia solution (TAS) allows patients to avoid general anesthesia and alleviates pain. TAS is a liquid mixture of highly diluted lidocaine and adrenaline, and the subcutaneous infiltration of a large amount of TAS surrounding the veins swells and toughens the target tissue, which can alleviate pain and protect the surrounding tissue from heat damage.[8] Previous studies have demonstrated that the temperature of TAS does not affect the occlusion rate of the treated veins; however, low temperature TAS might cause further vein contraction, and the cold effect surrounding the veins might reduce both the heat damage around the blood vessels and postoperative pain.

Over the past 2 years, our hospital used TAS-assisted EVLA to treat lower limb varicose veins and achieved satisfactory efficacy. In this study, we used a pain score to investigate the effect of TAS temperature on intraoperative and postoperative pain. Also we summarized the key points of operation and nursing implications, which could provide a reference for medical institutions planning on using this treatment method.

Nursing Coordination

Preoperative Preparation and Nursing Care

PREOPERATIVE VISIT. After the operation time was set, responsible nursing staff provided relevant education to the patients, informed the patients of the general operation procedures and the possible discomfort that might occur during the perioperative period, instructed the patients how to cooperate with the treatment, and helped to reduce patient anxiety. The patients were asked to reduce their preoperative activities. When staying in bed, the patients' lower limbs were raised. The ulcer condition of the lower limbs was observed, and medications to speed up scabbing were used when necessary so that the ulcer could heal before the operation.

ABSTENTION OF EATING AND DRINKING. Soft food was allowed 8 hours before the operation, and liquid food was allowed 2 hours before the operation.

MARKING OF THE OPERATION AREA AND THE PREPARATION OF THE SKIN. Before the operation, the ipsilateral limb was cleaned. Ultrasonography was used to locate the lesion, and under the guidance of the surgeon, the greater saphenous vein that would undergo laser treatment was marked. The skin of patients with more hair on their lower limbs was prepared.

PREOPERATIVE SEDATION. Ten to 15 minutes before surgery, the patient was intravenously injected with 10 mg of diazepam.

Intraoperative Nursing Coordination

INTRAOPERATIVE COORDINATION BY THE ROVING NURSE. The roving nurse helped the surgeon set the patient's body position and disinfect the skin. This nurse closely monitored the operation progress, helped to add or replace all required devices during the operation, correctly connected and fixed various wires or tubing, and avoided contamination. The nurse prepared the TAS accurately, labeled the bag containing the prepared TAS immediately with eye-catching marks to prevent it from being mixed with other liquids, recorded the amount of TAS used, and notified the surgeon immediately of the amount of TAS used. The nurse adjusted the laser treatment device according to the surgeon's requirement, set an appropriate power, and recorded the working process and time of device use. The nurse monitored changes in the patient's vital signs closely.

INTRAOPERATIVE COORDINATION BY THE INSTRUMENT NURSE. The instrument nurse prepared sterile devices and a table as well as inventoried the surgical devices. The nurse mastered the names and uses of the various devices required for the surgery and understood the surgical procedure. The nurse placed the devices and the items needed for surgery on the sterile table and was able to predict the devices and items needed for the next step to assist the surgeon in completing the operation.

Postoperative Handling and Care

Twenty-four hours after the EVLA surgery, an elastic bandage was used for eccentric compression. Attention was paid to a suitable tightness, and we often used a tightness that could fit one finger as the standard. Attention was paid to the blood supply at the extremity of the ipsilateral limb. The following indicators were observed to determine whether deep vein thrombosis was present: skin temperature, swelling, skin color, dorsalis pedis pulse, body surface sensation, and the perception of the ipsilateral limb. After the surgery, the patient assumed the supine position with the ipsilateral limb raised, and early ambulation was encouraged. If no specific discomfort was present, then the patient was able to leave the bed immediately after the surgery. We recommended that the patients walk regularly during the recovery period, with an average time interval of 1 to 3 hours.[7] Within 1 month after surgery, the patients were required to wear elastic stockings on their ipsilateral limbs. The diameter of the ipsilateral limb was measured first to select the appropriate size elastic stockings. The patients were instructed to wear their elastic stockings properly for more than 12 hours each day, and they were told to avoid standing for long periods.

Methods

Clinical Information

All patients underwent ultrasonography to evaluate the deep and superficial veins of both lower limbs, and the clinical-etiology-anatomy-pathophysiology (CEAP) classification[9] grades were determined. Patients with reflux in the greater saphenous vein were included. For patients with varicose veins in both lower limbs, only one leg was treated during a single treatment, and the other leg was treated at least 2 weeks later.

The recruited 51 patients were randomly divided into two groups. For group A (n = 26), room temperature (24°C) TAS was used surrounding the greater saphenous vein to conduct local swelling anesthesia. For group B (n = 25), cold (4°C) TAS was used. The distance between the laser fiber and the skin, the diameter and the length of the treated vein, the amount of TAS used, the energy transferred, and other parameters were recorded intraoperatively. All patients used an 11-point numerical rating scale (NRS)[10] ranging from 0 to 10 to assess their perioperative pain from high to low, where 10 represented the most severe pain, and 0 represented no pain. The patients selected various scores to quantify the degree of pain, and higher scores represented greater degrees of pain; 1 to 3 represented mild pain, 4 to 6 represented moderate pain, and 7 to 10 represented severe pain. On the same day after the surgery and over the three following days, the pain condition and off-bed activities of each day were recorded. If the patients were unable to move, then they were asked whether it was because of pain.

Treatment Process

All patients who were treated with EVLA received 1 mg of midazolam for intravenous sedation and

inhaled oxygen during the perioperative period. The patients assumed the supine position, and all greater saphenous veins underwent percutaneous puncture with a 22G micropuncture needle under the guidance of ultrasonography. The puncture site was approximately 2 to 3 cm above the knee level. Then, a guidewire entered the blood vessel through the puncture needle, a 5F guiding sheath entered the greater saphenous vein via the guidewire, and a 600-mm optical fiber passed the puncture site and entered the vein. EVLA was performed using a 1,470-nm laser diode. The injection of TAS was conducted under the guidance of ultrasonography, and the TAS formula was 500 mL of normal saline, 20 mL of 0.5% lidocaine, 1 mL of 1:1,000 adrenaline, and 20 mM of sodium bicarbonate. Laser treatment was applied in a continuous mode, with an energy range of 6 to 8 W. After laser cauterization and after the greater saphenous vein was confirmed to be occluded using ultrasonography, the optical fiber was withdrawn. After 24 hours of surgery, an elastic bandage was used to conduct eccentric compression. After the treatment, the patient was encouraged to be active. If postoperative pain occurred, then 500 mg of acetaminophen was given.

Statistical Methods

SPSS 20.0 (IBM, Armonk, NY) was used for data analysis, and all data were represented as means ± standard deviations. A *t* test was used to compare normally distributed data between the two groups. NRS scores were examined using paired sample *t* tests, and $P < .05$ was considered as a significant difference.

Results

The number of cases in groups A and B were 26 and 25, respectively. Clinical data are shown in Table 1, and CEAP grades are shown in Table 2. There was no difference between the two groups with regard to the above indicators ($P > .05$).

Treatment data are shown in Table 3. No significant difference was observed between the two groups ($P > .05$), and the treated great saphenous veins of all patients in both groups achieved complete occlusion after treatment.

During the surgery, the percentage of patients who felt pain in groups A and B were 69.2% and 36%, respectively. The percentage of patients in group A who did not feel pain in the surgery was lower than that of group B. Figure 1 shows a histogram comparing the average NRS scores of patients from both groups. The average NRS scores of group A on the day of surgery and 3 days after the surgery were higher than those of group B, and this difference was significant ($P < .05$). The scores for group A were significantly higher than those for group B ($P < .05$).

Table 4 describes the resumption of patients' daily activities in both groups after surgery. On the first postoperative day, only 30.8% of patients in group A completely resumed their daily activities, whereas 68% of those in group B did so. The percentage of patients who resumed their daily activities in group A was lower than that of group B. On the second and third postoperative days, the number of patients who resumed their daily activities did not significantly differ between groups; however, the percentage of those who recovered in group A remained lower than that of group B. Most of the patients were unable to resume their normal activities because of pain, and a small proportion of these cases were because of fatigue or heaviness of the lower limbs.

Table 1. Clinical Data of the Patients in the Two Groups

	Group A	Group B
Number	26	25
Male-to-female ratio	10:16	11:14
Average age	44.6 ± 6.9 y	45.3 ± 7.2 y
Average body mass index	27.2 ± 3.3	26.6 ± 3.1
Average depth between puncture site and skin	3.1 ± 1.6 cm	3.3 ± 1.5 cm
Average diameter of great saphenous vein at saphenofemoral junction level	10.3 ± 2.9 mm	10.5 ± 3.1 mm
Average diameter of great saphenous vein at knee level	7.4 ± 2.6 mm	7.5 ± 2.5 mm

Table 2. CEAP Grades of the Patients in the Two Groups

CEAP Grades	Group A	Group B
C2	12	11
C3	5	6
C4	8	6
C5	1	2
C6	0	0
Total	26	25

CEAP, clinical-etiology-anatomy-pathophysiology.

There was no venous perforation, skin burns, or other severe complications in either patient group; nor was there any deep vein thrombosis, phlebitis, or surgical area infection postoperatively. On average, all patients were discharged 3 days after surgery. Before discharge, a review of the ultrasonography showed that the veins treated via laser ablation were closed, the varicose veins were filled with thrombus, the intima was thickened, the lumen collapsed under pressure, and blood did not flow through it.

Discussion

Tumescence anesthesia is widely used in many areas; in addition to EVLA, it is used in vascular surgery, breast surgery, orthopaedic surgery, and others.[11,12] The advantage of tumescence anesthesia lies in the reduction of both bleeding and pain. Bleeding is reduced because of the vasoconstrictive role of adrenaline and the compression effect on the veins of tumescence, whereas the reduction in pain is the combined effect of lidocaine and sodium bicarbonate. The EVLA process has three goals for local TAS. First, the tissue surrounding the vein is anesthetized, and the diluted anesthesia drug infiltrates along the gaps around the great saphenous vein to anesthetize the nerves around the cauterization area, effectively reducing pain. For some patients, no other auxiliary anesthesia is needed. In this study, no patient used auxiliary epidural anesthesia or general anesthesia. Second, the liquid surrounding the vein protects the adjacent tissue from the heat damage of the laser. One reason for this effect is that after the injection of TAS, the fascia gap around the great saphenous vein is widened, which increases the distance between the laser heating point and other tissues outside fascia (including the nerves, muscles, and skin) to achieve isolation protection and reduce both intraoperative pain and postoperative scars. The other reason is that TAS includes a large amount of water, and with its large specific heat capacity, water plays a protective role of a "radiator" for the surrounding tissues. Third, TAS was injected into the fascia gap surrounding the great saphenous vein to compress it. At the same time, the use of adrenaline causes venous contracture, so the laser head can have better contact with the venous wall, and the energy can be conducted better, which reduces damage to the venous endothelia at a lower energy.

The infiltration of TAS surrounding the great saphenous vein usually starts before ablation, and it diffuses rapidly, possibly reducing its radiator role.[13] To address this issue, Memetoglu et al[14] suggested injecting TAS both before the beginning of laser treatment and providing a continuous injection during EVLA treatment. TAS also protects the skin from the heat damage of the laser because it moves the skin farther away from the vein. In addition, because the vein is close to the catheter, the energy transfer is more effective, and almost all the blood is discharged out of the vein, thereby preventing the occurrence of thrombophlebitis.

Table 3. Treatment Data of the Patients in the Two Groups

	Group A	Group B
Length of the treated great saphenous vein	38.5 ± 5.9 cm	36.5 ± 6.3 cm
Applied laser energy	8 W	8 W
LEED	62.1 ± 7.8 J/cm	59.4 ± 8.3 J/cm
Total energy for each ipsilateral limb	1,926 ± 274 J	1,893 ± 259 J
Amount of TAS used for each ipsilateral limb	168 ± 34 mL	155 ± 29 mL

TAS, tumescence anesthesia solution.

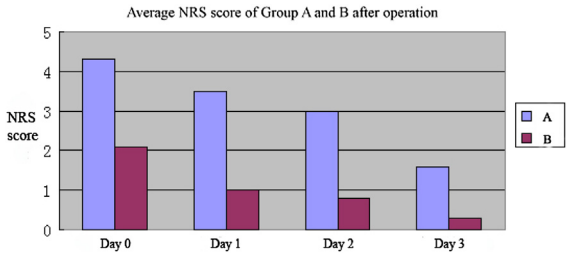

Figure 1. The average postoperative NRS scores of patients in both groups A and B. NRS, numerical rating scale. This figure is available in color online at www.jopan.org.

Pannier et al[15] conducted a prospective randomized controlled trial, in which the patients were randomly divided into two groups: 42 patients used warm TAS, 43 patients used cold TAS, and all patients were reviewed on days 1, 10, and 30 with regard to their clinical and therapeutic complications and occlusions. That report showed that under high average linear endovenous energy density (LEED), the temperature of TAS did not affect the occlusion rate and that the patients in the cold TAS group tended to have less pain and needed significantly fewer painkillers.

Therefore, scholars have examined the temperature of TAS. Tarhan et al[16] tested two laser wavelengths for EVLA and used TAS at two temperatures (4°C and 24°C) to observe the changes in the penetration rate caused by cold TAS. Regardless of the laser wavelength, they found that the laser penetration rate was better when the TAS was cold. Dumantepe and Uyar[17] divided 101 ipsilateral limbs into two groups according to the temperature of TAS (the cold TAS group and the room temperature group), and the results showed that patients in the cold TAS group needed fewer painkillers; the cold TAS surrounding the vein had a protection effect on the overheating of the surrounding tissues caused by the laser treatment; and the patients in the cold TAS group had fewer postoperative complications. Of the patients who were unable to resume normal activities 2 days after surgery, 64% of the room temperature group and 14% of the cold TAS group could not resume normal activities because of pain. Chong et al[18] used a cold saline infiltration to replace local anesthesia. Cold saline infiltration can replace local anesthesia infiltration to avoid the risk of local anesthesia; this technique did not affect the short-term effect of EVLA. The results of the present study showed that patients who received cold TAS had less postoperative pain than those who received room temperature TAS, and they were able to resume normal activities sooner. These results are consistent with those of the aforementioned studies. One limitation is that we only documented this information of the day of surgery and 3 days after surgery in this study. The long-term effects require additional study.

Comprehensive Nursing Care

Because surgical nurses must cooperate intraoperatively with the surgeon to inject the TAS, they must also master the TAS injection method. First, they must understand the anatomy of the injection area, and locate the muscle gap surrounding the great saphenous vein where the great saphenous vein forms a special structure (ie, the "Egyptian eye"). While injecting, the nurse should do so into this whole structure, generally using the continuous pressurized dripping method. Attention should be paid to the following items during operation: (1) Under ultrasonography, when the

Table 4. The Numbers and Percentages of Patients in Both Groups who Resumed Their Daily Activities at Various Time Periods After the Surgery

	Number of Patients in Group A who Resumed Their Daily Activities	Percentage of Patients in Group A who Resumed Their Daily Activities	Number of Patients in Group B who Resumed Their Daily Activities	Percentage of Patients in Group B who Resumed Their Daily Activities
Postoperative day 1	8	30.8%	17	68%
Postoperative day 2	5	50%	3	80%
Postoperative day 3	3	61.5%	3	92%

thin needle is used for puncture, the puncture of the skin should be fast because TAS contains adrenaline. (2) The needle can be adjusted in the tissue, and the injection can be performed near the great saphenous vein until the surrounding tissue becomes hypoechoic under ultrasonography. (3) If the TAS is injected into the blood vessels, in it will generally not be an issue, although it causes a contraction effect on the blood vessels. Because the amount of TAS is low, there should be no systemic response. (4) After the injection of TAS before laser ablation, ultrasonography verification should be performed.

For pain management, pain scoring can be used to observe the perioperative pain of patients, and corresponding interventions should be implemented in a timely manner. Before the operation, nurses should receive information regarding the pain tolerance of patients and their preoperative pain, which can help to correctly anticipate intraoperative and postoperative pain. Analgesics can be given accordingly, which can help smooth the progress of surgery. After the comparison of the preoperative pain assessment, changes in the patient's pain should be detected immediately. Through sufficient care, adequate attention should be given to the patient's pain throughout the treatment process. Pain scoring enables more targeted perioperative care, thereby improving the medical quality of the procedure.

Because this method differs from traditional surgical methods, the instruments and devices used are different, and the preoperative preparation has corresponding changes, nursing staffs must perform more detailed work in cooperation with the doctor to implement this treatment. In general, patients do not know much about this method, and the ward nurse must answer each patient's questions during the preoperative visits, inform them about the advancement and safety of this technique to dispel their concerns, and instruct them to use correct manner of cooperating with the treatment. In this study, the nursing staffs of the ward and the operating room performed close observation during the treatment of patients, including those of patients' symptoms, signs, and psychological status, starting with their clinical details to provide the doctors with first-hand information to assist smooth diagnosis and treatment processes.

Conclusions

The application of TAS during the treatment of lower limb varicose veins via EVLA improves patient safety and comfort; cold TAS reduces intraoperative and postoperative pain more effectively than room temperature TAS; thorough and comprehensive perioperative nursing on the ward and in the operating room also plays an important role during the entire treatment.

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