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ENDOVENOUS LASER ABLATION OF VARICOSE VEINS: EVOLUTION, TECHNIQUE, RECENT ADVANCES AND FUTURE

KEY WORDS: Endovenous, laser, varicose, fiber, ablation.

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ABSTRACT

Endovenous Laser Ablation (EVLA), since its inception, has been touted as a paradigm shifting technique in the treatment of lower limb venous varicosities, and has indeed shown much promise in being more efficacious and less risky than conventional 'stripping and ligation' surgical therapy; with improved durability of result, reduced patient morbidity, improved patient compliance and post-procedure quality of life. With standardization of the procedure and greater availability, EVLA is poised to become a mainstream option for therapy of varicose veins. In this review article, we focus on the technique of EVLA, the evolution of the procedure, entail a few recent advances in its usage, the challenges the technique faces and their ramifications in the technique's future.

Introduction:

A landmark overturn in the long-established invasive surgical protocol for lower limb varicosities was set in motion at the turn of the century, when the first paper entailing the usage of endoluminal laser venous ablation was first published by Magi G et al[1], though its popularization is largely attributed to Dr. Carlos Boné[2]. Being US-FDA approved in 2002, the EVLA technique has been rapid in its posing a challenge to conventional surgical methods such as stripping and ligation of Greater Saphenous Vein (GSV) and Short Saphenous Vein (SSV) varicosities: up to 70% procedures performed for lower limb varicosities now consist of endoluminal techniques[3].

The first literature review was published in 2004 by M. Perrin et al[4], in which was concluded that the short-term results of endovenous therapy and invasive surgery were comparable, with the added advantage of reduced morbidity for the former. Follow-up performed over the course of more than 10 years of early cases has slowly revealed the efficacious nature of EVLA[5.] Though many later studies have not yet attained the minimum-required follow-up time of 3-5 years, what is evident currently is the fact that the number of contraindications related to venous anatomy/ diameter are few, the procedure is simple and is less fraught with peri- and post-operative complications, and faster convalescence when compared to its surgical counterpart.

Initially reserved for solely the GSV, forays were made into extending this line of therapy to include SSV varicosities as well[6]. The GSV is the preferred target due to its implication in a majority of cases of lower limb varicosity, its ease of access and navigable anatomy. The SSV, however, has been slower to catch on, primarily due to the risk of associated damage to the saphenous nerve (the incidence of which is on the decline due to improvement in technique).

The common indications for EVLA include aesthetic disturbance by varicosities, leg ache and heaviness, lipodermatosclerosis, venous ulceration, recurrent superficial thrombophlebitis and external bleeding. Contraindications include presence of deep venous thrombosis, presence of a bleeding diathesis and local infection.

EVLA functions by causing laser-mediated photo-destruction of the vein from within its lumen, thus causing its collapse and subsequent luminal thrombosis. Produced by diodes, the various laser wavelengths utilized for said ablation are 810nm, 940nm, 980nm, 1064nm, 1320nm and 1470nm. The primary target chromophore of the 810 and 940nm lasers is hemoglobin, while the higher wavelength lasers primarily target water. In the latter, the laser energy is absorbed partly by the water in the blood, as well as the vessel wall, thus limiting the spread of energy much beyond the vessel wall. This reduces post-operative complications and pain[7].

EVLA Technique

Continuous efforts have been made in improving the efficacy and safety of EVLA, since its introduction to clinical practice. The initial theorized mechanism of its function was proposed to be due to direct contact of the laser tip with the vessel wall. As a result, the technique was performed with an aim of maximizing vessel wall-fiber contact, including venous compression and slow pullback time. This prolonged contact time was associated with increased pain and bruising[8]. Compression, along with pulsed-energy lasers, used initially, were gradually phased out and replaced with continuous-energy lasers, which was followed by a reduction in post-operative complications[9-11.]

The current EVLA technique is largely an outpatient-procedure, usually not requiring hospital admission. The patient is placed supine, and the affected lower limb is abducted and slightly flexed at the knee to allow for easier access of the GSV along the limb's medial aspect.

Once adequate antiseptic painting and draping is performed, the caudal-most aspect of the GSV is punctured using a vascular access kit, under US guidance. Care should be taken if a local anesthetic such as lidocaine is to be administered prior to the puncture, as the same may result in vasospasm of the GSV, making vascular puncture considerably more difficult. If vasospasm occurs, it may be relieved through warm massages, the proximal application of a tourniquet, dependent limb positioning or the use of nitropaste. Once puncture is achieved, skin wheals with local anesthesia are made every 10 or so centimeters from the site of puncture heading cranially, to allow for subsequent instillation of tumescent perivenous anesthesia. The vascular sheath and dilator are then removed, and the treatment sheath is advanced to a point distal to the superficial epigastric vein, or 20mm distal to the SFJ. Next, tumescent anesthesia is administered with a mixture of 440cc normal saline, 25cc 1% lidocaine and 10cc 7.5% sodium bicarbonate. This mixture is delivered, under US guidance into the saphenous sheath. If administered correctly, the GSV should appear centrally within a dark pool of anesthetic.

The laser fiber is then introduced through the sheath in place. An appropriate wattage on the laser generator is selected, and the laser fiber is activated via foot pedal. Care should be taken to continually withdraw the fiber at a pullback rate of 2mm/s, while monitoring the ablation response via ultrasound. The ablation should be ceased as the fiber tip approaches the puncture site, to prevent superficial injury to the skin and subcutaneous tissue.

After the procedure, compression bandages are applied from the ankle to the groin, along with concurrent application of full-length compression stockings. Patients are required to follow-up at our clinic post-op day 2, 1 month and 6months after the procedure to monitor adequate closure of the GSV and rule out formation of deep venous thrombus.

Complications include deep venous thrombosis, superficial bruising and injury to skin/ subcutaneous tissue, saphenous nerve injury and phlebitis.

Technical Parameters and their Evolution

Power and Linear Endovenous Energy Density (LEED): Power is the measure of the amount of energy used, and LEED, is a linear metric that measures the amount of energy delivered per unit length of the vein. Proebstle et al investigated the effect of power and LEED on treatment efficacy using a 940nm probe, and concluded an inverse correlation between the power used, the LEED and treatment failure[12]. Durability of ablation was also positively correlated with the power and LEED. Largely through trial and error, Timpermann et al[13], Theivacumar et al[14] and Panier et al[15] concluded that the trade-off between procedural efficacy and post-operative pain/bruising could be achieved with a LEED of 60-100 J/cm.

Type of Laser Fiber Tip: The originally conceived laser tips were bare, to enable direct contact with the vessel wall. This, however, caused greater incidence of venous perforation. As a circumvention, jacketed tips were introduced in the metallic and ceramic variants[16, 17]. The jacket enables up to a 15-degree divergence in the laser beam, which consequently diminishes its perforative nature. Also, the jacket provides a physical barrier between the laser beam and the vessel wall. An improvement upon such a beam-limiting jacket was the advent of radial fibers, wherein light diffusion by a prism at the probe tip allows a 360-degree projection. A new development is the radial 2ring fiber (ELVeS Radial 2ring™ fiber, CeramOptec GmbH, Germany), which utilizes two prisms placed at the fiber tip 6mm apart to create two radial laser beams. Hirokawa et al[25] concluded that the 2ring fibers had similar efficacy as bare-tip fibers, with lesser incidence of postoperative pain and bruising.

Wavelength of Laser Light: A spectrum of laser wavelengths were investigated for usage in EVLA, with the lower frequencies being 810, 940, 980, and 1064 nm. As mentioned earlier, these low frequencies utilize hemoglobin as the chromophore, and hence are known as the Hemoglobin Specific WaveLengths (HSWL). Subsequently, higher wavelengths targeting the water in blood and vessel wall were developed (1320 and 1470nm), which are Water Specific WaveLengths (WSWL)[18]. WSWL lasers are more efficient in transmitting energy, and hence require lower power settings[19-21]. Kabnick et al[21] and Mauriello et al[3] concluded that, keeping the LEED and power constant, post-operative pain and bruising were significantly reduced in fibers with higher wavelengths (i.e. WSWL).

Recent Advances in EVLA

López D'Ambola et al[22] utilised a 1470nm diode laser in a no-contact method of ablating superficial varicosities, utilizing water as internal chromophore, and hypertonic saline infusion as the external chromophore, with promising results.

Kendall et al[23] have reported the usage of EVLA in the treatment of anomalous, ectatic marginal veins of the lower limbs in toddlers with Klippel-Trenaunay Syndrome, without complications.

Pre-operative venous mapping has been shown to be a predictor of the occurrence of Endovenous Heat-Induced Thrombosis (EHIT), in a study performed by Judith C et al[24], where the incidence of EHIT was noted to be significantly greater in GSV diameters in excess of 8mm.

Challenges Faced by, and the Future of EVLA

Most treatment failures are evident within the first six-months of the procedure, with recanalization of the GSV. This has a marked tendency to occur in the proximal aspect of the GSV, as it is here that the central venous pressure is greatest. This is coupled with the inability of the vein to adequately undergo vasospasm at this segment. Another significant challenge has been the lack of standardization for the procedure, lack of availability of adequate infrastructure and the often-exorbitant cost involved in its implementation. Significant strides have been made in under two decades since the commencement of clinical usage of EVLA. Continuous efforts are being made with the cornerstone of efforts being standardization of laser energies and reduction of post-operative discomfort.

Conclusion

EVLA, since its inception, has been touted as a paradigm shifting technique in the treatment of lower limb venous varicosities, and has indeed shown much promise in being comparable, if not better, than conventional 'stripping and ligation' surgical therapy; with durability of result, reduced patient morbidity, improved patient compliance and post-procedure quality of life. As the future unfolds, greater evidence to support the above would come forth; and with standardization of the procedure and greater availability, EVLA is poised to become a mainstream option for therapy of varicose veins.

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