Update on Endovenous Laser Ablation: 2011

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Abstract

In 2001, the use of endovenous laser ablation (EVLA) was introduced to the United States to treat superficial venous insufficiency. EVLA has subsequently undergone a rapid rise in popularity and usage with a concomitant decrease in traditional operative saphenectomy. Since its inception, the use of EVLA to treat superficial venous insufficiency has advanced significantly. The efficacy of treatment has been validated using both hemoglobin-specific laser wavelength and water-specific laser wavelength lasers. Currently, laser optimization is focusing on reducing postprocedural sequelae. The clinical parameters that correlate best with improved postoperative recovery use lower power/energy settings, water-specific laser wavelength lasers, and jacket or radial-emitting tips. Future study is still required to assess the durability of treatment at lower power and energy settings coupled with jacket or radial-emitting tip fibers. Long-term follow-up using duplex imaging is recommended to ensure persistent treatment success.

Keywords

venous ablation, laser, varicose veins, saphenous vein

Introduction

The use of endovenous laser ablation (EVLA) to treat superficial venous insufficiency was introduced to the United States in 2001. EVLA has subsequently undergone a rapid rise in popularity and usage with a concomitant decrease in traditional operative saphenectomy. The preferential use of EVLA may be attributed to its minimally invasive nature and to the ability to perform the procedure in an ambulatory setting while maintaining efficacy and durability. Rapid progression in technique and technology has characterized the growth of EVLA since its inception. Moreover, the treatment parameters that have demonstrated significance in altering patient outcomes include power, wavelength, linear endovenous energy density (LEED), and a type of fiber tip. The following review will delineate the evolution and current state of the treatment of superficial venous insufficiency using EVLA.

Advances in Technique and Technology

The initial theorized mechanism of action of EVLA was attributed to direct contact of the laser fiber with the vein wall. To maximize laser fiber and vein wall contact, the procedures were performed initially using compression and a slow pull-back time. The increased contact time was associated with a significant increase in pain and bruising. Pulsed energy lasers were also used initially, and pain and bruising led to significant postoperative sequelae. Lasers that emitted continuous energy were used preferentially thereafter, and they resulted in a decrease in postprocedural side effects.[1-3] In vitro studies helped corroborate the posited mechanism of vein wall perforation as being the source of postprocedural pain and bruising.[4] Consequently, compression and pulsed energy lasers were no longer used as part of the standard EVLA procedure. Moreover, modifications to technique and technology have since focused on reducing the incidence of vein wall perforation to minimize subsequent pain and bruising.

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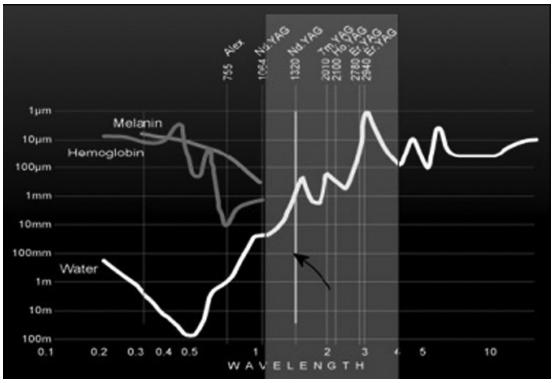

Figure 1. Water-specific laser wavelengths

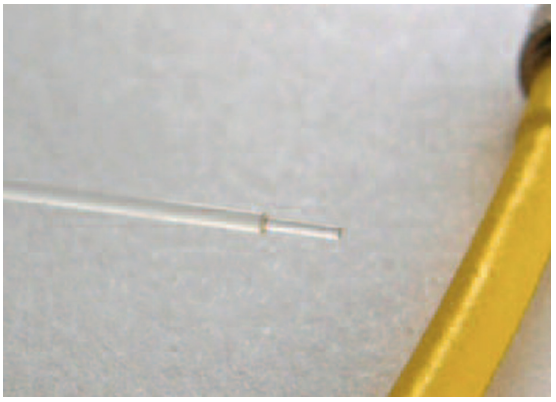

Figure 2. Bare-tip fiber

Procedural Parameters

Power and LEED

The power correlates directly with the energy used (ie, power = energy/time). LEED is defined as the energy delivered per cm of target vein (J/cm). The LEED represents a metric with which to assess the amount of energy delivered to a segment of vein wall.[5]

Wavelength

A spectrum of laser wavelengths has been used for the treatment of venous insufficiency using EVLA. The initial wavelengths were on the lower end of the spectrum: 810, 940, 980, and 1064 nm.[6] The lower wavelengths function by targeting hemoglobin as the chromophore. Thereafter, a combination of heat and steam bubbles is produced resulting in endothelial destruction and thrombotic occlusion without necessitating direct contact between the laser fiber tip and the vein wall. This was confirmed in vitro, where steam bubbles were only formed in hemolyzed blood and not in saline or plasma.[4] Consequently, these wavelengths are referred to as hemoglobin-specific laser wavelengths (HSLW; Figure 1).[7]

The realization that lasers with increasing wavelength exhibit an increasing affinity for water as a chromophore brought about the use of higher wavelength lasers: 1320 and 1470 nm. These are referred to as the water-specific laser wavelengths (WSLW; Figure 1).[7] Their proposed mechanism of action consists of targeting the water within the vein wall directly and, thereby, causing direct damage to the intima. Since water as the chromophore is more efficient for energy absorption than hemoglobin by a factor of 40, lower levels of power are required to achieve the same LEED and to effect venous ablation.[8-10]

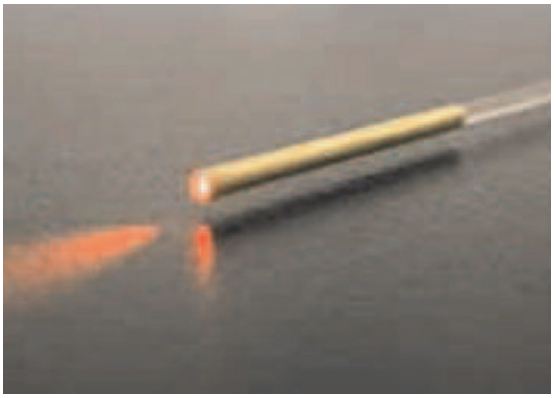

Figure 3. Jacket-tip fiber

Type of Fiber Tip

The original lasers used bare-tip fibers (Figure 2). The bare tips came in direct contact with the vein wall, which resulted in vein wall perforation and increased pain and bruising. To mechanically eliminate direct contact with the vein wall, jacket-tip laser fibers were created. These include ceramic and metallic jacket tips.[11,12] The metallic jacket tip is configured to result in a 15° divergence of the emitted light, which increases the fiber diameter from 600 µm to an effective diameter of 905 µm (Figure 3). This results in a diminished power density, thereby changing the mechanism of ablation from a cutting to a coagulation mode. Moreover, the metallic tip provides for a physical barrier of 0.010 in. between the fiber tip and the vein wall.[13] In addition, a radial-emitting fiber tip has been created. This allows the laser energy to be side firing in a

360° fashion. Acting as a diffusion fiber, this reduces the power density with all the advantages inherent in the design.[14]

Evolution in Power and LEED

To evaluate the effect of power on the efficacy of EVLA, Proebstle et al[5] compared treatments using a 940 nm laser at the power settings of 15 W and 30 W. The lower power group had an average LEED of 18.4 J/cm, and the higher power group had an average LEED of 68.4 J/cm. At 3 months follow-up, 11 treatment failures were reported in the 15 W group, and none were reported in the 30 W group. Postprocedural pain and bruising did not differ but were elevated in both groups (72% to 82%). Another study was performed using a 1470 nm laser, and the power settings of 15 W and 25 W were compared. The average LEED for both groups were 109.7 J/cm and 132.6 J/cm, respectively.[15] There were no treatment failures in both groups. Once again, pain and bruising were significant in both groups. To further evaluate the association between power and postprocedural symptoms, one study compared EVLA using a 1320 nm laser at 5 W and 8 W but with the same LEED.[16] The 5 W group exhibited significantly fewer side effects as compared with the 8 W group. Efficacy of treatment was equivalent between the 2 groups.

Studies have also demonstrated a strong correlation between LEED values and efficacy and durability of treatment using EVLA. Some of the original data accrued by Timperman et al[17,18] using an 810 nm wavelength laser demonstrated that patients treated using a LEED > 80 J/cm achieved more durable outcomes as compared with patients treated using a LEED < 80 J/cm. Moreover, there were no differences in side effects. Another study also using an 810 nm wavelength laser concluded that efficacy could be achieved with LEED values >60 J/cm.[19] An evaluation of the 1470 nm laser demonstrated 100% treatment efficacy with an average LEED of 107 J/cm. However, a subset analysis demonstrated an increased incidence of paresthesias when the LEED was >100 J/cm as compared with <100 J/cm (15.5% vs 2.3%).[20] Therefore, it is reasonable to perform EVLA with a target LEED ranging between 60 and 100 J/cm to ensure treatment efficacy while minimizing postprocedural symptoms.

Evolution in Laser Wavelengths

One of the initial studies to evaluate wavelength with regard to efficacy and postprocedural symptoms compared the 810 nm and 980 nm lasers, both HSLW lasers. The treatment groups were standardized to the same LEED. Kabnick[10] found that treatment success did not differ significantly between the 2 groups; at 1-week and 4-month follow-ups, the 980 nm group exhibited significantly less pain and bruising as compared with the 810 nm group. To further evaluate the relationship between increasing wavelength and postprocedural symptoms, the 1320 nm WSLW laser (power = 8 W) was evaluated against the 940 nm (power = 15 W or 30 W) laser.[16] The differences in power were necessary to compare equivalent LEEDs. The average LEED in the 1320 nm group was 62 J/cm, and the average LEED in the 940 nm group was 63 J/cm at 30 W. Efficacy of treatment did not differ between the 2 groups. However, the 1320 nm group exhibited significantly less pain and bruising as compared with the 940 nm/30 W group. Mackay et al[6] drew similar conclusions from a study that treated bilateral lower extremity venous insufficiency. In the study, each patient was treated using both modalities, the 1320 nm laser in one leg and the 810 nm laser in the other leg. The LEEDs were kept equivalent at 80 J/cm. Efficacy was equivalent for both groups, but the postprocedural pain and bruising scores were lower in the 1320 nm group. With regard to the 1470 nm laser, Mauriello et al[21] reported preliminary data on a retrospective review of 50 patients, which demonstrated that lower power (3-7 W) and energies (mean LEED 25.9 J/cm) were sufficient for treatment efficacy while minimizing pain and bruising. Anecdotal reports of immediate postprocedural sonographic vein wall changes and a diminished requirement for tumescent anesthesia have also been reported with the 1470 nm laser.[21] Moreover, as an analogue to a positive control, another study that evaluated the 1470 nm laser at higher powers and LEEDs, 15 W (LEED 107 J/cm) and 25 W (LEED 129 J/cm), demonstrated significant postprocedural pain and a high rate of paresthesias at 1 year (7.6%).[22]

Evolution in Fiber Tip

One randomized study that evaluated the efficacy of a jacket-tip laser was performed using the 980 nm laser. Forty-five patients were placed into groups that were treated with a bare-tip 980 nm laser or a jacket-tip 980 nm laser. The target power and LEED were the same in both groups (12 W and 100 J/cm). There were no treatment failures in either group, but the pain scores were significantly lower (approximately one half) in the jacket-tip group as compared to the bare-tip group.[13,23] To evaluate a WSLW laser and the effect of a change in fiber tip, one study was performed using the 1470 nm laser with either a bare tip (LEED 97 J/cm), jacket tip (LEED 104 J/cm), or a radial-emitting tip (LEED 77 J/cm). As a surrogate for treatment efficacy, decrease in vein diameter was assessed. The vein diameter decreases in the 3 groups were as follows: bare tip (38%), jacket tip (55%), and

radial tip (40%).[14] Moreover, pain was lower in the group treated using the radial-emitting tip, suggesting that the radial-emitting tip exhibits equivalent efficacy to the bare tip while using a lower LEED and causing less postprocedural pain.

Durability of EVLA

Multiple trials have evaluated and established the durability of EVLA. A recent multicenter registry initiated by the International Endovenous Laser Working Group evaluated the long-term outcomes for the treatment of saphenous vein insufficiency using EVLA.[24] Data from 1020 limbs treated using a 980 nm bare-tip laser were compiled from 11 centers in the United States and Europe. Duplex imaging was used to evaluate for treatment failure (ie, reflux confined to the saphenous junction, the main trunk, or both). Kaplan–Meier analysis revealed cumulative failure rates of 7.7% at 1 year and 5.4% at 2 years with no additional reported cases of treatment failure at 3 years.

Summary

The use of EVLA to treat superficial venous insufficiency has progressed significantly since its inception. The efficacy of treatment has been validated using both HSLW and WSLW lasers, assuming that the treatments are delivered using optimal power and LEED parameters. The current focus is on reducing postprocedural sequelae. The clinical parameters that correlate best with improved symptomatology include lower power settings, the use of WSLW lasers, and the use of jacket or radial-emitting tips. Future study is still required to assess the durability of EVLA at lower power settings and to assess the durability of jacket and radial-emitting tip fibers. Long-term follow-up using duplex imaging is recommended to ensure persistent treatment success.

Declaration of Conflicting Interests

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