Overview

Background

Public interest in laser and light treatment of leg veins is high, and, under the right circumstances, excellent results can be achieved with this treatment modality. With any laser or light source treatment, reverse pressure from associated reticular or varicose veins must be recognized and eliminated; otherwise, the treatment is doomed to fail. Many patients benefit from a combination of treatments such as sclerotherapy, ambulatory phlebectomy, and intravascular laser or radiofrequency closure because external lasers and light sources do not effectively treat associated reticular and varicose veins. Lasers can be effective in treating vessels of less than 1-2 mm in diameter that are resistant to sclerotherapy and telangiectatic matting, which can occur postsclerotherapy. However, sclerotherapy remains the criterion standard for the treatment of leg veins and telangiectasias.

Not until the development of the pulsed dye lasers (PDLs) in the late 1980s were the first reasonable results achieved on leg veins. Development over the last decade of longer wavelength, longer pulse duration pulsed lasers and light sources has greatly improved outcomes. Basic requirements for a laser or a light source to treat leg veins are a wavelength that is proportionately better absorbed by the target (hemoglobin) than surrounding chromophores and penetration to the full depth of the target blood vessel. Sufficient energy must be delivered to damage the vessel without damaging the overlying skin, and this must be delivered over an exposure time long enough to slowly coagulate the vessel and its lining without damaging surrounding tissue.

The choice of wavelength and pulse duration is related to the type and the size of the target vessel. Deeper vessels require a longer wavelength to allow penetration to their depth. Pulse duration must be matched to vessel size; the larger the vessel diameter, the longer pulse duration required to effectively damage the vessel thermally. To be most effective, thermal injury must encompass the full thickness and circumference of the vein wall endothelium, rather than just the most superficial aspect of the vein wall. The relative importance of the hemoglobin absorption peaks in green (541 nm) and red to infrared (800-1000 nm) shifts as the depth and the size of the blood vessel changes. Absorption by hemoglobin in the long-visible to near-infrared range appears to become more important for vessels more than 0.5 mm and at least 0.5 mm below the skin surface.

The following related Medscape Reference articles may be of interest:

- Varicose Vein Treatment With Endovenous Laser Therapy
- Varicose Veins and Spider Veins
- Radiofrequency Ablation Therapy for Varicose Veins
- Complications of Dermatologic Laser Surgery

History

Carbon dioxide lasers were used early in an effort to obliterate telangiectatic vessels by means of vaporization with a small spot size. Absorption properties of the carbon dioxide laser light cause nonspecific thermal injury because the chromophore is water. Because water is in all tissues around the targeted blood vessel, scarring with a poor cosmetic result is the outcome. Hence, studies using carbon dioxide lasers have demonstrated unsatisfactory cosmetic results.

Argon (488 nm and 514 nm) and continuous-wave dye lasers (515-590 nm) have also been used historically because they are well absorbed by hemoglobin and penetrate to the depth of middermal vessels, more than 1 mm into the skin. Nonspecific thermal damage is the result of the longer or continuous pulses heating up surrounding tissue nonspecifically. The results of treatment of leg veins using these wavelengths have been discouraging, even with the addition of skin cooling.

Continuously running Nd:YAG lasers were also tried when they were first brought to the medical marketplace. Results were poor secondary to nonspecific heating of surrounding water and the large depth of penetration (up to 3.7 mm).
Indications
Lasers are typically reserved for the smallest telangiectasias of the leg, but newer longer-wavelength lasers can be useful for spider veins up to 2 mm in diameter, although they produce much more pain than when small-diameter vessels are treated. The typical treatment sequence for patients with spider veins is to treat axial (saphenous) varicosities if present, followed by branch varicosities, and then reticular veins, which are first treated using appropriate surgical means (ie, intravascular laser or radiofrequency closure and/or ambulatory phlebectomy) or sclerotherapy. Once these vessels are adequately treated, lasers have the greatest utility in a "clean-up" role, on vessels smaller than the diameter of a 30-gauge needle.
Additionally, lasers are a good option to treat vessels resistant to sclerotherapy. Laser and light source treatments should be considered in a primary role (prior to superficial sclerotherapy) in certain patients, such as those who are fearful of needles or who do not tolerate sclerotherapy (extremely rare in the authors' more than 30 years of experience), patients whose vessels do not respond to sclerotherapy (also extremely rare when appropriate diagnosis and treatment of feeding reticular veins has occurred), or those who are prone to postsclerotherapy telangiectatic matting. Most importantly, lasers should be considered in patients who are not willing to commit to postsclerotherapy usage of compression stockings. Because thermal injury of the vein endothelium is essentially immediate, compression has not been shown to enhance the efficacy of treatment, as has been shown with sclerotherapy.

Technology
The primary lasers used for bright-red, small (0.5 mm or smaller) leg veins are the pulsed visible light lasers or intense pulsed light (IPL) sources. Lasers tried on 0.5-mm or larger leg veins are near-infrared pulsed lasers. Lasers that have reported to be effective include green (potassium titanyl phosphate [KTP] 532 nm), yellow pulsed dye (585-605 nm), alexandrite (infrared, 755 nm), diode (infrared, 810 nm), Nd:YAG (infrared to 1064 nm), and the IPL broadband light source (515-1200 nm). Most recently, 940-nm diode lasers have been shown to have efficacy in the treatment of leg veins. These lasers have all been designed with large spot sizes, typically 3-8 mm in diameter, and with pulse durations of 2-100 milliseconds to match the thermal relaxation time of larger telangiectasias. Most incorporate a mechanism to cool the skin to allow higher fluence to be delivered with less chance of inadvertent injury to the epidermis. The pulsed KTP 532-nm laser is used for bright-red vessels. The 532-nm light is well absorbed by oxygenated hemoglobin and the penetration depth of no more than 0.75 mm is ideal for superficial capillaries. With the pulsed KTP laser, the most positive results have been achieved by using larger spot sizes (3-5 mm) and longer pulse durations of 10-50 milliseconds at fluences of 14-20 J/cm².

PDL (585 nm, 450-millisecond pulse duration) is highly effective in treating a variety of cutaneous vascular lesions, especially facial telangiectasias and port wine stains. PDL is less effective for leg veins. Although 595-nm light can penetrate 1.2 mm to reach the typical depth of leg telangiectasias, the pulse duration is inadequate to effectively damage all but superficial fine vessels approximately 0.1 mm or smaller in diameter. Immediate purpura is also a consequence of treatment, which results in prolonged hyperpigmentation, more so than when treated with sclerotherapy.

Long-PDLs (ie, 585 nm, 590 nm, 595 nm, 600 nm) are capable of deeper penetration into the skin, and pulse durations from 1.5-40 milliseconds allow for thermal destruction of vessels corresponding to the size of the leg telangiectasias.

Long-pulse alexandrite lasers (755 nm) have been modified to allow pulse durations of up to 20 milliseconds or longer. This wavelength theoretically penetrates to a depth of 2-3 mm. Optimal treatment parameters for long-pulse alexandrite lasers appear to be 20 J/cm², double pulsed at a repetition rate of 1 Hz. In one study, medium-diameter vessels (0.4-1 mm) responded best and small-diameter vessels responded poorly.

Diode lasers generate coherent monochromatic light through excitation of small diodes. A group of 810-nm diode lasers (5-250-millisecond pulse duration) have been used with encouraging results in the treatment of superficial and deep small- to medium-sized leg telangiectasias. The concept behind using near-infrared wavelengths lies not only in the deeper penetration of this wavelength and in the decreased melanin absorption but also, and most importantly, in the tertiary hemoglobin absorption peak that occurs at 915 nm, for which deoxygenated hemoglobin is the target. By choosing these longer wavelengths, even deeper vessels up to 3 mm below the surface (eg, feeder, reticular veins) can theoretically be treated, and, by varying the pulse width from a few milliseconds to several hundred milliseconds, a variety of different-sized vessels can also be targeted.

Results of leg vein treatment using a 930-nm pulsed diode laser that is closer to the 915-nm hemoglobin absorption peak have also been encouraging. The single significant adverse effect of pain may limit use of this wavelength, and this characteristic of pain is shared by many of the near-infrared lasers. The 940-nm diode laser shows a decreased incidence of pain and a better response in vessels between 0.8-1.4 mm.
Combined use of radiofrequency with a diode laser to treat leg veins has shown no better long-term results than lasers alone. Trelles et al treated 40 patients with skin types II-IV with a maximum of 3 treatments on 1-to-4-mm leg veins at 2-week intervals with a 900-nm diode laser (250 millisecond exposure time, average fluence 60 J/cm²) and radiofrequency (energy 100 J/cm²). The 6-month assessment showed greater than 80% clearance of treated vessels, based on clinician assessment. Reproducibility of this study has been difficult, and the combined use of radiofrequency ablation has not been independently evaluated.

Long-pulsed Nd:YAG 1064-nm lasers target deep, relatively large-caliber, dermal and subdermal vessels. The primary benefit of this wavelength is its deep penetration and the relatively low absorption by melanin. Treatment of vessels in skin of color is therefore theoretically possible. However, high energies must be used for adequate penetration. Only with sufficient fluence and facilitation of heat dissipation can the posterior wall of a larger diameter (1-2 mm) vessel filled with deoxygenated hemoglobin be reached and heated.

In general, treatment with long-pulsed 1064-nm laser light is relatively painful and requires cooling and topical anesthesia. Large-caliber vessels, more than 0.5 mm in diameter, respond best. Vessels up to 2 mm (rarely up to 3 mm) can be treated with long-pulsed Nd:YAG lasers. Some of the effects of hydrostatic pressure may be addressed by treating these larger vessels, although the pain experienced by patients significantly increases beyond a vessel that is 2 mm in diameter. Data suggest that by using smaller spots and even higher fluences, even small vessels respond. In the authors’ initial studies, optimal settings were fluences of 80-120 J/cm² and single pulse durations of 10-30 milliseconds. For patient comfort and epidermal sparing, some type of cooling must be used, whether in the form of contact cooling, cryogen cooling, or cold gel.

The IPL laser was developed as a device to treat ectatic blood vessels. By using noncoherent light emanating from a filtered flashlamp, pulse durations can be manipulated to match thermal relaxation times of vessels larger than 0.2 mm in diameter, and filters can be used to remove lower wavelengths of visible light. Fluences can be very high, with the unit delivering as much as 90 J/cm². Sequential pulsing of 1- to 12-millisecond duration separated and synchronized with 1- to 100-millisecond rest intervals delivers wavelengths of 515-1000 nm. It is most commonly used with the 550- and 570-nm filters to deliver primarily yellow and red wavelengths with some infrared.

The therapeutic potential of IPL is explained by the optical properties of hemoglobin as the size and the depth of its container (blood vessel) and the state of oxygenation are changed. As the size of the vessel increases to 1 mm in diameter, it absorbs more than 67% of light, even at wavelengths longer than 600 nm. This absorption band is even more significant for blood vessels that are 2 mm in diameter. Thus, a light source higher than 600 nm should result in deeper penetration of thermal energy, thereby allowing much absorption by deoxygenated hemoglobin. The reason for this effect is that the absorption coefficient in blood is higher than that of the surrounding tissue for wavelengths from 600-1000 nm.

A device that produces noncoherent light as a continuous spectrum longer than 550 nm is thought to have multiple advantages over a single wavelength laser system. These advantages include absorption by both oxygenated hemoglobin and deoxygenated hemoglobin and by larger blood vessels located deeper in the dermis being affected. Additional advantages have been a larger spot size and a relatively low incidence of purpura, but disadvantages are risks of pigment changes when these devices are not operated by expert users.

**Technique**

KTP laser requires using fluences of 12-20 J/cm² delivered with a spot size of 3-5 mm in diameter, as a train of pulses is delivered over the vessel until spasm or thrombosis occurs. For leg vessels smaller than 1 mm in diameter that are not directly connected to a feeding reticular vein and with the use of a tip chilled to 4°C to protect the epidermis, this method may be effective. The authors found that 2-3 treatments were necessary for maximal vessel improvement, although some have reported 100% resolution of the treated leg vein with 1 treatment. Patients with darker or tanned skin have a relatively high risk of temporary hyperpigmentation or hypopigmentation in the authors’ experience.

When using the long-pulsed Nd:YAG laser, protective eyewear is critical; it is one of the most penetrating and damaging to the retina. Treatment with long-pulsed 1064-nm lasers is painful; therefore, cooling and either topical anesthesia or local anesthesia are necessary. In the direct-contact method, minimal pressure is placed against the skin. In some cases in which a larger reticular vein is targeted for 1064-nm laser, slight pressure may be used to minimize the total diameter of the vein to allow greater penetration and less total heat accumulation by reducing target size. This also may make the treatment slightly less painful. When treating small-caliber vessels, immediate disappearance is often seen; however, when treating blue, larger-caliber vessels, often the only change is spasm of the treated vessel.

Another method involves the off-skin technique, which works with some devices that permit a defocused beam or a divergent collimated beam to be used for treatment. A small layer of gel is placed on the skin, and the crystal or the fiber delivering the laser energy is held 1-3 cm off the skin. This method causes a sudden
change in interface from air to water and results in more lateral spread than deep heating. Increased visualization, larger area of coverage, and better response by small vessels are the advantages, but greater heat accumulation closer to the surface is the main disadvantage.

Some 1064-nm lasers use a cryogen spray immediately before, during, and/or after the laser pulse, so that improved patient comfort and increased epidermal protection is provided. Higher fluences can then be delivered and excellent visibility during treatment is maintained. Although cold injury, with resultant pigmentation changes, could theoretically occur, the key to safety and increased patient comfort is to allow each pulse to be separated by at least 2-3 mm and to keep the cumulative cryogen time to less than 40 milliseconds.

When using older IPL devices, a thick layer of gel must be placed onto the crystal, and absolutely no pressure should be applied as the crystal is placed over the target area, floating the crystal in the gel. Plastic spacers are available to increase the uniformity of the distance of the crystal and the thickness of the gel, although most users simply float the crystal holding the weight of the IPL head in their hands. Newer IPL devices such as the Lumenis One have a thermoelectrically cooled sapphire crystal, which requires contact with the skin and a minimal amount of clear coupling gel between the crystal and epidermis. It is highly recommended that IPL devices with built-in skin cooling are used for the treatment of leg veins. For patients who have Fitzpatrick skin types I-II with very fine, red telangiectasias, acceptable results can usually be obtained. When large areas are involved, the large spot size of the IPL allows rapid treatment. To minimize rectangular foot printing, a 10% overlap of pulse placement is used, or, alternatively, a second pass may be performed with the direction 90° from the original direction.

Clinical Endpoints
Regardless of the laser equipment used, some features and pitfalls are common to all devices. For effective treatment, the physician should observe the immediate visual endpoint darkening of the targeted vessel, followed by urtication within 10 minutes and loss of the visual vessel margins. With some of the infrared lasers, such as the 1064-nm laser, observing immediate, transient vessel contraction is achievable, but, for most lasers, urtication continues to evolve for as long as 30 minutes. Blanching of the skin should be avoided with all devices. Importantly, avoid the temptation to overtreat the vessels, with multiple unnecessary passes or overly high fluences. This leads to epidermal blanching/graying and, ultimately, necrosis with hyperpigmentation or hypopigmentation. In the authors’ experience, epidermal injury is most likely to occur with IPL devices without cooling.

When using the 1064-nm laser, lateral spread of the heat energy within the vessel wall to nearby connecting vessels is observed. Because of this, overlap of the treated areas is not necessary, and pulses should be spaced more than 1 mm apart. This is analogous to "spot welding" the vein and is adequate to achieve vessel clearance. For other laser wavelengths, as many as 3 passes may be performed over the treated areas. Photoprotection with sun avoidance and/or sunscreens is very important for 3-4 weeks following treatment in order to minimize the appearance of postinflammatory hyperpigmentation.

Postoperative Results
After laser treatment of leg veins, the patient seldom experiences postoperative pain. Pain medication is usually not required. Smaller vessels may have disappeared completely, affording the patient and the physician with a visual record of success. Larger spider veins and reticular veins usually do not disappear following treatment, and they may even darken as the blood in the vessels coagulates. Use of the 1064-nm laser may cause mild edema or surrounding erythema around the treatment site, which usually resolves rapidly (see image below). Compression for a defined period following treatment may be helpful in achieving maximal benefit, but it is not mandatory, as it is with sclerotherapy. Posttreatment hyperpigmentation is often seen for 1-3 months and should be discussed with patients as an expected occurrence prior to treatment. The incidence of hyperpigmentation increases with the size of the treated vessel. In the authors’ experience, unlike sclerotherapy, which usually can effectively clear a blood vessel in 1-2 treatments, laser therapy often requires 3 or more treatments to effect a similar degree of improvement.
Complications
One of the greatest pitfalls for the novice laser user is the temptation to re-treat the area when no instantaneous changes are apparent. Treatment with the lowest effective fluence is recommended. One should wait several minutes after the initial pulse to assess the effects of the fluence and pulse duration chosen. In patients with darker skin types, postoperative pigmentary changes are possible and usually resolve within 4-6 months. Follow-up care is minimal. Care must be taken to reduce fluence by 20% in the malleolar area because of reflection from the periosteum and the thinned, stretched dermis (in comparison to the rest of the leg). Skin breakdown rarely occurs from excessive heat accumulation. If ulceration occurs, conservative daily wound care with moist dressings is recommended. Patients should be counseled that ulcers may take 6-10 weeks to heal and will likely leave a hypopigmented scar. Occlusive hydrocolloid dressings can be used and are left in place for 48-96 hours at a time. Necrotic tissue can be gently debrided to facilitate reepithelialization. Pain is usually controlled with oral nonsteroidal anti-inflammatory drugs.

Summary
Laser treatment of leg veins and telangiectasia has been the subject of much patient and physician interest. Although laser technology continues to evolve and improve, optimal results for leg telangiectasias may often be achieved with sclerotherapy or sclerotherapy followed by laser or IPL therapy. The authors’ experience has borne out that sclerotherapy is more efficient and effective for most patients with telangiectatic leg veins. Combination treatment allows sclerotherapy to treat the larger, feeding venous system, while laser or IPL effectively seals the superficial vessels to prevent extravasation, thereby theoretically minimizing pigmentary changes, recanalization, and telangiectatic matting.
Longer wavelengths (eg, 1064 nm), used at pulse durations of 10-50 milliseconds, improve the capability of lasers to treat larger, deeper deoxygenated blood vessels. This wavelength minimizes the risk to the epidermis, even when patients are tanned. Other wavelengths and systems have been made safer with the addition of epidermal cooling systems.