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Laser therapy for leg veins

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Abstract Visible veins on the leg are a common cosmetic concern affecting approximately 80% of women in the United States (Engel A, Johnson MI, Haynes SG. Health effects of sunlight exposure in the United States: results from the first national health and nutrition examination survey, 1971-1974. *Arch Dermatol* 1988;124:72-9). Without a quick and noninvasive treatment available, leg veins present a therapeutic challenge. This challenge has been tackled by the design of lasers with longer pulse durations, and the use of lasers with longer wavelengths and cooling devices. Recent studies show the efficacy of laser treatment beginning to approach that of sclerotherapy, the gold standard. This review outlines the principles guiding laser treatment, the current available options, and a clinically oriented approach to treating leg veins.
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Introduction

In the 1980s, argon lasers were used, but the 488-nm wavelength was strongly absorbed by melanin.[1] Also, argon lasers were continuous lasers that did not allow for selective heating of vessels, so scarring was common.[2]

In 1983, Anderson and Parrish's[3] principles of selective photothermolysis guided the design of the pulsed dye laser (PDL), which successfully treated facial telangiectasias and port-wine stains. Although a 577-nm wavelength was originally chosen to match the yellow absorption peak of oxyhemoglobin, it was quickly realized that a 585-nm wavelength resulted in more effective treatment of port-wine stains.[4]

A second generation of PDLs with a longer wavelength (595 nm) and longer pulse duration (1.5 milliseconds) was released in 1996. These PDLs penetrated deeper but were still only effective for vessels up to 1 mm in depth and 1 mm in width.[5] Over the past 5 years, near-infrared lasers targeting the broad absorption band from 750 to 1100 nm have been used to penetrate further. The longer wavelength alexandrite, diode, and Nd:YAG permit sufficient energy to heat deeper leg veins up to 3 mm wide.

Anatomy

The lower extremities contain both superficial and deep veins. The superficial venous system consists of the greater saphenous vein draining most of the leg, the lesser saphenous vein draining the posterior and lateral lower leg, and the lateral (subdermic) venous system draining the lateral leg above and below the knee. The superficial venous system

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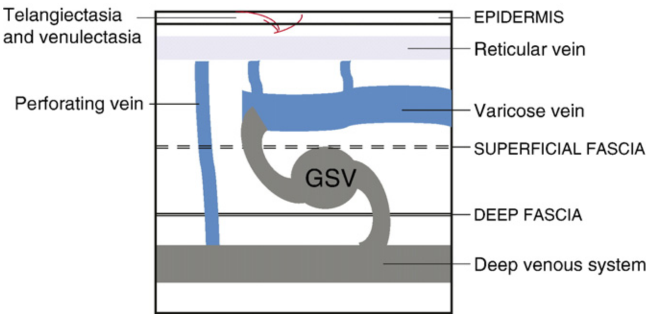

Fig. 1 Microanatomy of lateral subdermic venous system. Great saphenous vein (GSV) located beneath the superficial fascia. Distal tributaries become varicose veins. Adapted from George Somjen, MD, in Weiss et al.[7]

lies within the superficial fascia in the subcutis. These veins connect to perforating veins that penetrate the deep fascia and connect with the deep venous system within the muscle. The deep venous system is composed of the femoral vein, popliteal vein, and deep veins of the calf.

One-way valves direct the flow of venous blood upward and inward to deep veins, and eventually to the heart. Aging, genetics, hormones, pregnancy, upright posture, and trauma can contribute to failure of venous valves, resulting in leakage from deep veins to relatively lower-pressure superficial veins and their unnamed tributaries.[6]

Clinically, this is seen as visible veins. Dilations of the most superficial veins are called telangiectasias. These are usually bright red and measure 0.03 to 0.3 mm in diameter. These vessels can become dilated *after* sclerotherapy or laser treatment, and in this scenario, are referred to as telangiectatic matting. Slightly larger are postcapillary venulectasias, which measure 0.4 to 2 mm, and may be red or blue depending on their oxygenation. Telangiectasias and venulectasias are commonly referred to as spider veins. These connect to larger reticular veins measuring 2 to 4 mm that are typically blue because of the Tyndall effect and their deeper location within the dermis. Varicose veins are tributaries to the named superficial venous system that, because of their location just above the superficial fascia, are prone to dilation manifest as protuberant and tortuous blue veins (Fig. 1).[6,7]

Patients may report pain, burning, muscle fatigue and cramping, and restless legs. Symptoms may worsen with heat, menses, pregnancy, oral contraceptive use, or hormone replacement therapy. They do not correlate with the size of visible varices or volume of reflux. Over time, retrograde flow results in chronic venous insufficiency, seen as edema, hyperpigmentation, stasis dermatitis, and ulceration.[7]

Selective photothermolysis and leg veins

Selective photothermolysis encompasses 3 concepts to achieve focal thermal injury and minimize damage to surrounding structures. (1) Wavelength is chosen for preferential absorption by the intended tissue chromophore. (2) Pulse duration must be shorter than the thermal relaxation time of the target. (Thermal relaxation time is defined as the time needed for the target structure to cool to one half of its peak temperature after being irradiated.) (3) Fluence should be high enough to cause thermal injury to the desired skin structure.[3]

In treating vascular lesions, the target chromophore is oxyhemoglobin, which has 3 major absorption peaks at 418, 542, and 577 nm. There is also a broader and less selective absorption peak spanning 750 to 1100 nm (Fig. 2).[6] The 3 selective peaks in the green and yellow range are targeted

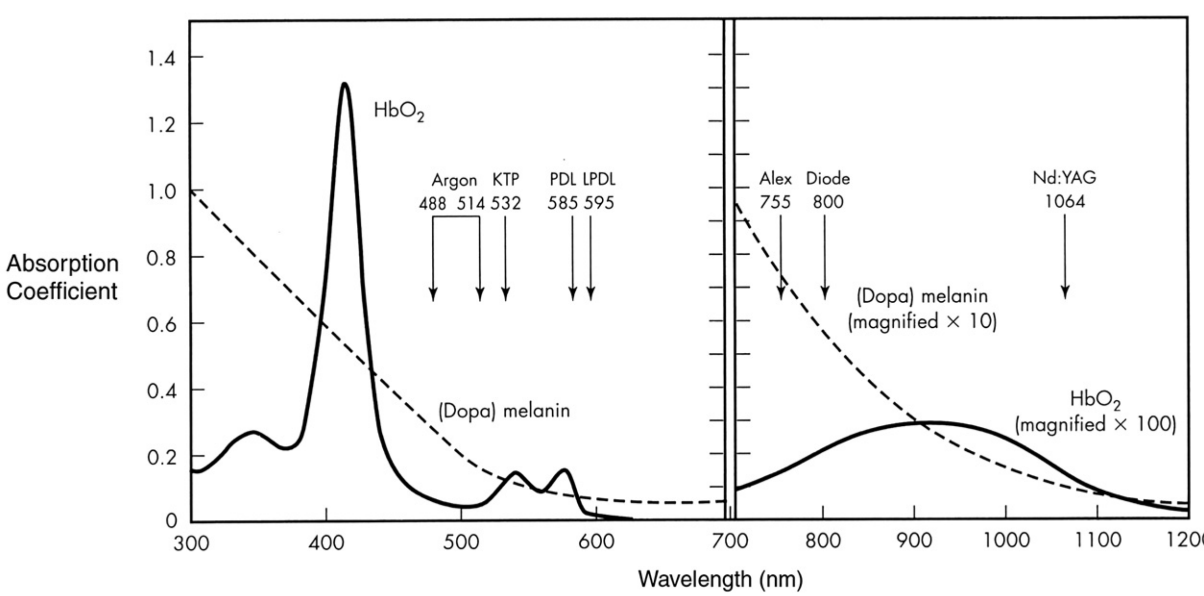

Fig. 2 Schematic absorption spectrum of hemoglobin, oxyhemoglobin (HbO_2), and melanin. Adapted from Anderson RR, Parrish JA. The optics of human skin. In: Regan JD, Parrish JA, editors. The science of photomedicine. New York: Plenum; 1980.

by the PDL laser, and somewhat by intense pulsed light (IPL) sources. Although less specific, light in the 700- to 1100-nm range better penetrates the dermis to uniformly heat the full circumference of the vessel and results in vein closure, whereas shorter wavelengths heat only the anterior vessel wall and result in incomplete thrombosis.[8] One caveat is that wavelengths greater than 900 nm are less specific and also target water, so higher fluences are required, which can cause unwanted damage to surrounding tissue unless cooling devices are used.

Longer pulse durations than those that are used to treat port-wine stains are required to heat leg veins, which are comparatively larger in diameter. Most abnormal leg veins are 0.1 to 4 mm in diameter. A typical 1-mm vessel has a thermal relaxation time of 360 milliseconds, so theoretically, any pulse duration less than 180 milliseconds could be used. Altshuler's extended theory of selective photothermolysis predicts that because a leg vein is a nonuniform target (damage to the weaker-absorbing vessel wall occurs after heat diffuses from the stronger-absorbing hemoglobin), a pulse duration longer than the thermal relaxation time will be needed.[9] In practice, pulse durations of 10 to 100 milliseconds are most commonly used, with longer pulse durations less likely to induce vessel rupture and side effects.

Fluences are chosen to raise the temperature inside the vessel to more than 70°C, the temperature at which blood coagulates. Previously, it was hypothesized that lasers worked by heating blood so that steam bubbles formed, then collapsed, causing vessel rupture, a process termed *cavitation*. It is now believed that vessel damage can occur either by vessel contraction secondary to collagen shrinkage or by thrombosis followed by inflammation and fibrosis.[8] Biopsies immediately after, and 4 weeks after, laser treatment show fragmented elastic fibers and thrombosis. Heat shock protein and transforming growth factor β may be mediators of collagen remodeling, fibrosis, and ultimately, vessel destruction.[10]

Spot size influences how much energy reaches the desired target: larger spot sizes make up for the scatter of light that inevitably occurs once light enters the skin. Because the 1064-nm laser already penetrates deeply, the smallest adequate spot size is chosen to avoid heating surrounding tissue and excess pain.

Side effects

The most common side effect when treating leg veins is purpura. This occurs when the temperature and pressure is high enough to cause cavitation, which results in vessel rupture, hemorrhage, and purpura. Spreading the delivered energy out over a larger spot size or over a longer pulse will help. Still, delayed purpura can occur days later secondary to an unrelated vasculitic process.

Another common side effect is hyperpigmentation and hypopigmentation. There are now a multitude of skin cooling devices to prevent unwanted epidermal heating and melanin absorption: cryogen spray, sapphire windows, copper plates, refrigerated air, aluminum rollers, and cold gels. These also alleviate pain.

Other side effects include mild pruritus, erythema, edema, blistering, scarring, recurrence, and telangiectatic matting. Telangiectatic matting is a new cluster of fine vessels at the site of previous sclerotherapy, vein stripping, or less frequently, laser therapy. This may be due to hypoxia-induced neovascularization, or increased collateral flow and dilation of preexisting more superficial vessels.[11] It may be related to degree of inflammation, inadequate post-therapy compression, or exogenous estrogen. Fortunately, telangiectatic matting usually spontaneously resolves over 3 to 12 months.[12,13]

Available laser options

The assortment of lasers and light-based sources available to treat telangiectasias and superficial leg veins is constantly growing. There are increasingly more adaptations to existing laser models to better target the challenging leg vein. The most appropriate technique will depend on the size and depth of the vessel, as well as the skin color, expectations, and lifestyle of the patient. Frequently, patients will have a heterogenous group of vessels of varying depth, caliber, and oxygenation necessitating a multimodality approach.

Potassium titanyl phosphate laser

The potassium titanyl phosphate (KTP) laser's 532-nm wavelength matched the second oxyhemoglobin absorption peak and was a natural choice for vascular lesions. This shorter wavelength, however, was absorbed by melanin and resulted in frequent hyperpigmentation and hypopigmentation. A study of 56 patients with spider veins treated with 3 sessions of the KTP laser showed moderate efficacy in treating veins less than 0.7 mm in width: 33% had complete response, 40% had a visible decrease in vessel diameter, and 27% had no change. Vessels with larger diameters did not respond. Hyperpigmentation occurred in 23% of patients.[14]

Fournier's study of the KTP in multpulse mode (3 stacked pulses of 100-, 30-, and 30-millisecond duration, each separated by 250 milliseconds), with a fluence of 60 J/cm^2, a 0.75-mm collimated spot, and no cooling, applied to superficial 0.5- to 1-mm leg telangiectasias resulted in 53% vessel clearing after 1 treatment, 78% vessel clearing after 2 treatments, and 93% vessel clearing after 4 treatments. Although 18.2% of patients experienced hypopigmentation lasting a few months, no patient experienced hyperpigmentation. The nonuniform pulse sequenceh of decreasing pulse durations was postulated to maintain the temperature inside the vessel, without overheating the surrounding tissue.[15]

Generally, the KTP laser is effective for fine-caliber vessels and can be associated with a high frequency of dyspigmentation.

Long-pulse dye laser

The original PDL was built with a 585-nm wavelength and 0.45-millisecond pulse width to selectively target the superficial vessels in port-wine stains. This system proved to be ineffective in treating the larger and deeper vessels that make up most leg veins. A second generation of lasers with a longer 595-nm wavelength and a longer 1.5-millisecond pulse width was created to better treat leg veins, but for the most part is still only effective for smaller leg veins less than 1 or 1.5 mm thick.[5,16]

In an attempt to decrease the frequency of purpura, the PDL has recently been modified to be capable of an even longer pulse width. By doubling the number of subpulses within each pulse, there are now 8 consecutive subpulses that can be stretched out over 40 milliseconds. The laser can be tuned to 4 to 25 J/cm^2, and there are 2 available spot sizes (7 mm and 3 × 10 mm). In a study by Bernstein,[17] 15 subjects with 35 sites received 3 treatments, at 6-week intervals. Spider veins less than 1.5 mm were treated. An average fluence of 20.4 J/cm^2, a 3 × 10-mm spot size, pulse duration of 40 milliseconds, and dynamic cooling device were used. 44.4% achieved a marked (>50%) or excellent (>76%) response at 8 weeks after the final treatment. Side effects of edema, purpura, and erythema were rated as mild to moderate. Purpura was seen in 19% to 31% of treatment sites. Hyperpigmentation occurred in only 2 of 35 treatment sites after the first treatment, but fluences were raised, and hyperpigmentation occurred in 12 of 35 treatment sites after the second treatment. Vessel clearing was seen immediately posttreatment.

Kono's study of the long PDL demonstrated improved efficacy when treating smaller vessels. He used energy fluences from 10 to 20 J/cm^2 and pulse durations from 1.5 to 20 milliseconds. Complete clearance was seen in all vessels less than 0.2 mm, and in 13% of vessels 0.2 mm to 1 mm in size. Most patients with larger 1.1- to 2-mm vessels experienced 26% to 75% clearance. Of treated sites in this Asian population, 57.9% demonstrated hyperpigmentation.[18]

Tanghetti and Sherr[19] assessed the long PDL using a multipass technique. The PDL was used in conjunction with refrigerated air-cooling, a pulse width of 40 milliseconds, and fluences at or below the purpuric threshold (<16 J/cm^2). Up to 3 passes were administered until vessel disappearance or intravascular coagulation was observed. Of the targeted leg vessels, 80% exhibited 75% clearance after a single treatment, but purpuric doses were required to be efficacious, and 55% of leg veins treated exhibited hyperpigmentation.

The 595-nm PDL is an effective treatment for smaller-caliber (<1 mm) vessels, and the new longer-pulsed systems may be even more efficacious. The major drawbacks of this system are inability to treat larger veins, immediate purpura, and hyperpigmentation.

Alexandrite laser

The 755-nm wavelength has a high absorption coefficient for deoxygenated hemoglobin and a near-infrared wavelength that should permit deep penetration. McDaniel et al[20] investigated the alexandrite laser without cooling, using various parameters in 28 patients. They found the ideal settings to be a fluence of 20 J/cm^2 and a pulse duration of 20 milliseconds. After 3 treatments at 4-week intervals, medium vessels ranging from 0.4 to 1 mm responded best with a clearance rate of 48%. Telangiectasias less than 0.4 mm responded poorly, and the authors recommended sclerotherapy as an adjunct to treat smaller veins. Reported side effects were bruising, erythema, crusting, and hypopigmentation.

Kauvar and Lou[21] used higher fluences and added cryogen cooling to obtain better clearance rates. The 755-nm, 3-millisecond pulsed alexandrite laser was used with an 8-mm spot and fluences of 60 to 80 J/cm^2. Up to 3 passes were performed until the clinical end point of vessel disappearance or thrombus formation was reached. This end point was reached in all cases except in some vessels that were less than 0.5 mm in diameter. At 12 weeks, 51 sites were evaluated in 19 patients: 65% had greater than 75% improvement, 22% had 51% to 75% improvement, 10% had 26% to 50% improvement, and 4% had less than 25% improvement. Hyperpigmentation was the most common adverse effect, persisting in 26% of test sites beyond 12 weeks.

Cooling devices may enable higher fluences to be used with the alexandrite, a good option for medium vessels in patients with skin phototypes I to III. Telangiectatic matting can be severe and persistent.[22]

Diode lasers

Diode-based systems offer true continuous pulses of energy up to 250 milliseconds long. They provide near-infrared wavelength light that corresponds well to the tertiary hemoglobin peak. Compared to yellow light, it penetrates more deeply and is less absorbed by melanin, so it would be expected to effectively treat larger veins.

Indeed, in a study by Trelles et al,[23] the 800-nm diode gave the best results with larger vessels 3 to 4 mm in diameter. The 800-nm diode with pulse stacking (5 to 8 stacked pulses, pulse duration 50 milliseconds, delay 50 milliseconds), a 3-mm spot, and fluences of 210 to 336 J/cm^2 were used. Patients were treated every 2 months until complete clearance, with a maximum of 3 treatments. Of the treated patients, 60% achieved 50% to 74% improvement. Matting was seen in 2 patients. Hyperpigmentation was seen in 2 of 4 patients with skin phototype IV but resolved spontaneously by 6 months. Pulse stacking to heat the vessel incrementally was credited for decreasing pain; patients reported a high level of satisfaction even without anesthesia.

Wollina's prospective study of 35 patients with spider leg veins was unique in its attempt to follow patients for 1 year, although only 10 of 35 patients remained in the study for the full duration. He used the pulsed diode (810 nm), pulse width of 60 milliseconds, fluence of 80 of 100 J/cm^2, and a 12-mm spot size. Patients were treated twice, 14 days apart, and underwent skin biopsies and contact-free remittance spectroscopy. After 1 treatment, 15 patients had complete disappearance of spider leg veins. After 6 months, the complete response was maintained in 6 of the 15 patients. Effects at 1 year were stable compared to those seen at 6 months. Biopsies at 10 weeks, compared to baseline, showed decreased vascular areas. Spectral analysis showed decreased peaks for oxygenized hemoglobin immediately after laser treatment and this was maintained during follow-up. Patients did not experience purpura or pigment changes, but 2 patients developed mild scarring.[24]

Diode systems have also been used in conjunction with radiofrequency (RF) current. Unlike light energy, RF current is not dependent on specific wavelengths for hemoglobin absorption but instead flows to areas of high conductivity, such as heated blood.[25] By combining 900-nm diode pulses with RF current, lower fluences in the 60 J/cm^2 range can be used and less side effects may occur. Posttreatment histologic examination of 10 skin biopsies showed contracted vessels with hyalinization, suggesting that the combined 900-nm diode and RF current therapy is an effective treatment for leg veins.[26] A similar study combining the 915-nm diode with RF also demonstrated greater than 50% vessel clearance in 75% of patients.[25]

Nd:YAG laser

Over the past 5 years, the Nd:YAG has come into favor as a monomodality therapy capable of treating all leg veins up to 3 mm in size. The longer wavelength reaches deeper and larger veins, and combined with various cooling techniques, spares the epidermis.

A single treatment with a 1064-nm Nd:YAG, using a 50-millisecond pulse duration and a fluence of 100 J/cm^2, yielded 66% clearance in 75% of patients.[27] In a separate study, 2 treatments were given using 10- to 50-millisecond pulse durations and fluences of 90 to 187 J/cm^2. At 3 months, 71% of treated vessels had improvement graded as significant.[28]

A light wavelength of 1064 nm converts hemoglobin to the more spherically shaped methemoglobin, which has a 4 times higher absorption coefficient.[8,29] After initial irradiation, further energy is more effective at heating blood and the surrounding vessel.[30]

Mordon et al[31] showed that a multipulse system composed of an initial high-energy pulse followed by 2 lower-energy pulses resulted in efficient vessel closure. Of the targeted vessels, 98% cleared after 3 treatments, with no recurrences at 6 months. Of 28 treatment sites, 1 resulted in matting; and 1 of 11 patients experienced persistent hyperpigmentation.

Although there is still no consensus on the correct parameters to use, several authors have combined mathematical modeling with clinical experience to suggest optimal settings. Baumler et al[32] developed a mathematical model for the treatment of 1.5-mm-deep leg veins of various diameters. Maximal efficiency (ie, most of the applied energy was converted to vessel coagulation and not to nonspecific heating of extravascular tissue) was obtained using pulse durations of 10 to 100 milliseconds. Paulette et al[33] found a significant difference between pulse durations of 3 and 20 milliseconds, with a trend toward best efficacy at 60 milliseconds. Longer pulse durations were also associated with less purpura, edema, and hyperpigmentation.

Spot size and fluence should be chosen to achieve the end point of immediate vessel disappearance (vessel constriction) or bluing (vessel thrombosis). Lower fluences of 100 to 200 J/cm^2 work best for coagulation of larger vessels (1.5-3 mm); higher fluences of 250 to 400 J/cm^2 are required for smaller vessels ($<$1.5 mm).[34]

Eremia compared 3 lasers for the treatment of 0.3- to 3-mm leg veins: a 3-millisecond, cryogen spray–equipped 755-nm alexandrite; a sapphire window cooled super-long-pulse 810 diode, and a variable pulse width, cryogen spray–equipped 1064-nm Nd:YAG. Sixty-five sites in 30 female volunteers with skin types I to IV were treated. Greater than 75% improvement was achieved in 88% of the Nd:YAG-treated sites, 29% of the diode-treated sites, and 33% of the alexandrite-treated sites. Greater than 50% improvement was observed in 94% of the Nd:YAG sites, 33% of the diode sites, and 58% of the alexandrite sites. Although more effective, the Nd:YAG was also associated with more pain. In fact, 4 patients dropped out secondary to pain, stating they would prefer sclerotherapy. Furthermore, 3 of these 4 patients had initial vessel closure, but reopening of veins was observed at the 7- and 30-day follow-up. The authors extrapolated that the Nd:YAG was safe in all types of skin, the diode was safe in type IV skin, and the alexandrite was limited to nontanned type I to III skin.[22]

Perhaps the most important studies in the field of laser therapy for leg veins are those comparing the Nd:YAG with sclerotherpy. A representative study of 20 patients treated with injectable sodium tetradecyl sulfate on 1 leg, and long pulsed 1064-nm Nd:YAG on the other, showed better and faster responses in the sclerotherapy-treated legs.[35] Accordingly, sclerotherapy remains the gold standard for visible leg vein eradication. Recent small studies however hint that laser efficacy may be approaching that of sclerotherapy.

Levy conducted a study of 14 patients with leg telangiectasias ranging from 0.5 to 2 mm at 4 comparable sites: the first site was treated with one session of long pulsed Nd:YAG, the second site was treated with one session of sclerotherapy, the third site treated with laser then sclerotherapy 3 weeks later, and the last site treated with sclerotherapy then laser 3 weeks later. The Smartepil LS laser (Cynosure, Inc., Westford, MA, USA) was used with fluences between 100 and 125 J/cm^2, a fixed pulse width at 10 milliseconds, a 2.5-mm spot size, and optional ice packs. Although this was a small study, there were no significant differences between the 4 groups.[36]

Coles studied 20 patients with leg veins ranging from 0.25 to 3 mm at 2 comparable sites. One site was treated with sotradecol sclerotherapy and the other was treated with Nd:YAG laser (50-100 milliseconds, 130-190 J/cm^2, and 3 or 5 mm spot size). Nine patients received a second laser treatment at 8 weeks. Patients were followed for 3 months. Improvement was graded on a scale from 1 to 4, with 4 indicating greater than 75% clearing. The sclerotherapy-treated sites averaged a score of 2.3; the laser-treated sites averaged a score of 2.5. Of the treated patients, 45% preferred sclerotherapy because of the pain factor, whereas 35% of patients preferred laser, citing better vessel clearance and absence of hyperpigmentation.[37]

The Nd:YAG allows for monomodal treatment of most leg veins up to 3 or 4 mm in diameter. Longer pulse durations in the 20- to 60-millisecond range seem to be the most effective and associated with the least side effects. The effective volumetric heating achieved with this wavelength means there is a narrower window of safety; larger spot sizes can result in not only more pain but also overheating and ulceration.

Intense pulsed light

Unlike lasers, IPL systems simultaneously emit multiple wavelengths of light ranging from 500 to 1,000 nm. Each wavelength is emitted with a different intensity, and filters can be used to remove lower wavelengths. The temperature generated within a target blood vessel depends on the IPL spectral distribution. Baumler's mathematical model predicts that wavelengths both at the end of the visible end of the spectrum and at the near-infrared end of the spectrum should be effective in heating the entire vessel. Shorter wavelengths should be more effective at heating smaller vessels (0.6 or 1.5 mm). Longer wavelengths were slightly better at heating larger vessels (3 or 5 mm).[38] Theoretically, combining shorter and longer wavelengths could be used to treat smaller and larger vessels. In practice, IPL devices are commonly used with the 550- and 570-nm filters to deliver primarily yellow and red light, with a minor component of near-infrared light.[39]

Most studies report good clearance of smaller vessels. In a multicenter trial of 159 patients, Goldman reported 90% clearance rate with vessels less than 0.2 mm and 80% clearance rate with vessels 0.2 to 1 mm in diameter.[40] In another multicenter trial of 40 patients, Schroeter et al[41] reported a 92% clearance rate with vessels less than 0.2 mm and 80% to 81% clearance rate with vessels 0.2 to 1 mm.

Intense pulsed light seems to be most effective for superficial, red telangiectasias less than 1 mm. Broad spectrum light may be useful for simultaneously treating vascular and pigmented lesions, as in poikiloderma of Civatte.[39,42] The most common side effects are erythema, edema, mild burning, and if high fluences with short pulse widths are used, purpura and dyspigmentation.[40]

Clinical approach

A thorough history taking and examination is recommended. Associated symptoms, surgical history, and history of vascular disease should be obtained. Symptoms are usually improved with leg elevation or walking, whereas exacerbation of pain upon walking may be a sign of venous claudication. Physical examination includes the abdominal and pubic region. Other than around the foot and ankle, distended veins are usually evidence of venous pathology. Other findings suggestive of deeper venous reflux include asymmetry of limbs, scars indicating previous surgery or ulcers, and venous stasis changes.[7] There are multiple maneuvers described to help palpate reflux,[7,11,44] but these have been overshadowed by the advent of duplex ultrasound imaging. Many vein specialists advocate Doppler as part of every physical examination in patients presenting with venous disease to detect reflux.[7,11,43]

Reflux in the greater or lesser saphenous veins or large-diameter varicosities are indications for vein stripping or ambulatory phlebectomy.[44] Newer and less invasive alternatives are endovenous radiofrequency ablation (ERA) or endovenous laser therapy (EVLT). Initially, RFA was aimed at coagulation of blood and thrombus formation; RFA is now directed toward the vessel wall to induce collagen contraction.[7] As the vein wall contracts, the catheter is slowly withdrawn to induce vein collapse along the path of the exiting catheter. In 1999, Bone[45] reported the first successful use of EVLT to treat great saphenous vein reflux. Since then, multiple different laser wavelengths and modifications have been reported.

Patients seeking treatment of more superficial veins should be counseled that sclerotherapy remains the gold standard. Commonly used sclerosing agents include hypertonic saline, dextrose and hypertonic saline, polidocanol, sodium tetradecyl sulfate, polyiodinated iodine, chromated glycerin, and sodium salicylate.[7] Hypertonic solutions are not Food and Drug Administration–approved for sclerotherapy, but because they destroy the cell wall locally, they are frequently used. Detergent solutions, such as sodium tetradecyl sulfate, induce protein denaturation and disruption of the vessel cell surface membrane. The solution can be agitated to produce foam, which is believed to block the vessel so that the sclerosant stays within the intended treatment area. Finally, chemical irritants induce full-thickness vessel injury at the site of injection within seconds.[7] Good results are consistently achieved using various sclerosant types with appropriate concentrations and volumes.

Fig. 3 Lateral leg veins before and after 4 treatments with 1064-nm Nd:YAG.

Still, some patients may be better suited for laser therapy. Smaller veins not easily cannulated with a needle and vessels below the ankle prone to ulceration with sclerotherapy are best addressed with laser. Patients who have either failed sclerotherapy or developed telangiectatic matting are often referred for laser treatment. Finally, needle-phobic patients prefer laser, although the pain incurred is at least similar to that experienced with sclerotherapy.

The optimum laser wavelength depends on the type of leg vein that is being treated. Because the 1064-nm Nd:YAG works for almost all vessel sizes (up to 3 mm in diameter) and is safe in most skin types, it is a popular first choice (Fig. 3). The authors use the Altus long-pulsed 1064-nm Nd:YAG (Cutera, Brisbane, CA, USA) with the 5- or 7-mm spot size, and pulse durations of 20 to 40 milliseconds, to deliver fluences ranging from 110 to 150 J/cm^2. The higher end of this range is used for smaller vessels, whereas lower fluences are used for larger vessels. Pain can sometimes be an issue with larger veins, and the Zimmer air-cooling device may be helpful. Topical anesthetic creams can also be used. Second passes should be avoided to deter against overheating and ulceration. Depending on the vessel size and device used, approximately 3 treatment sessions may be required with treatment intervals of 1 to 2 months.

Medium-sized blue veins around the ankles are best eliminated with the alexandrite laser, which is considerably less painful than the Nd:YAG would be in this area.[46]

Tiny red spider veins in fair skin are reliably eliminated with a long PDL in combination with cryogen cooling. Candela's new Perfecta model (Candela Laser Corp., Wayland, MA, USA) may penetrate deeper and seems to be more effective in eliminating spider veins. Potassium titanyl phosphate lasers are also effective for vessels less than 1 mm in fair skin.

Telangiectatic matting secondary to previous therapy should be watched, as most spontaneously resolve. If matting persists, Kauvar recommends the central feeder first be treated with sclerotherapy or a 1064-nm Nd:YAG, then the remaining matting can be treated with a PDL, alexandrite, 595-nm Nd:YAG, or IPL. A tourniquet can be used to enlarge the vessels before treatment, or multiple passes can be used to improve efficacy.[46]

In addition to skin color and vessel size, pregnancy, medications, and age may be considered. Varicose vein therapy before conception may prevent progression that may occur during pregnancy.[47] If patients develop varicosities during pregnancy, Sumner[48] recommends waiting 6 to 12 weeks after delivery to allow varices to regress. The exact role of estrogen and progesterone in venous distensibility is unknown, so there are no recommendations as to whether patients should stop hormonal medications. Weiss writes that patients known to develop telangiectatic matting may consider temporarily stopping oral contraceptives or hormone replacement therapy for the duration of treatment. Although age is an independent risk factor for varicosities,[49,50] age may not be correlated to the efficacy of laser therapy.[23]

Posttreatment, patients with severe inflammation may be given fluticasone proprionate cream 0.05% to apply twice daily for up to 1 week. If larger veins are treated, patients are advised to wear thigh-high compression stockings, and immediately after procedure, to walk for 10 to 30 minutes. They should continue to wear stockings 24 hours per day for 2 weeks. Regular exercise, a high-fiber diet, and maintaining a healthy weight are recommended long term to help discourage new visible vein formation.

References

1. Apfelburg DB, Maser MR, Lash H, White DN, Flores JT. Use of the argon and carbon dioxide lasers for treating superficial venous varicosities of the lower extremity. Lasers Surg Med 1984;4:221-31.
2. Apfelburg DB, Maser MR, Lash H. Argon laser management of cutaneous vascular deformities. West J Med 1976;124:99-101.

3. Anderson RR, Parrish J. Selective photothermolysis: precise microsurgery by selective absorption of the pulsed radiation. Science 1983; 220:524-6.
4. Tan OT, Murray S, Urban AK. Action spectrum of vascular specific injury using pulsed radiation. J Invest Dermatol 1989;92:868-71.
5. Reichert D. Evaluation of the long-pulse dye laser for the treatment of leg telangiectasias. Dermatol Surg 1998;24:737-40.
6. Kauvar ANB, Khrom T. Laser treatment of leg veins. Semin Cutan Med Surg 2005;24:184-92.
7. Weiss RA, Feied CF, Weiss MA. Vein diagnosis and treatment: a comprehensive approach. New York: McGraw-Hill; 2001.
8. Ross EV, Domankevitz Y. Laser treatment of leg veins: physical mechanisms and theoretical considerations. Lasers Surg Med 2005;36: 105-16.
9. Altshuler GB, Anderson RR, Manstein D, Zenzie HH, Smirnov MZ. Extended theory of selective photothermolysis. Lasers Surg Med 2001; 29:416-32.
10. Sadick NS, Prieto VG, Shea CR, Nicholson J, McCaffrey T. Clinical and pathophysiologic correlates of 1064-nm Nd:YAG laser treatment of reticular veins and venulectasias. Arch Dermatol 2001;137:613-7.
11. Goldman MP, Bergan JJ. Sclerotherapy: treatment of varicose and telangiectatic leg veins. St. Louis: Mosby; 2001.
12. Duffy DM. Small vessel sclerotherapy: an overview. In: Callen JP, et al, editors. Advances in dermatology, vol. 3. Chicago: Mosby; 1988. p. 221-42.
13. Weiss RA, Weiss MA. Incidence of side effects in the treatment of telangiectasias by compression sclerotherapy: hypertonic saline vs. polidocanol. J Dermatol Surg Oncol 1990;16:800.
14. Spendel S, Prandl EC, Schintler MF, et al. Treatment of spider veins with the KTP (532 nm) laser—a prospective study. Lasers Surg Med 2002;31:194-201.
15. Fournier N, Brisot D, Mordon S. Treatment of leg telangiectases with a 532 nm KTP laser in multipulse mode. Dermatol Surg 2002;28: 564-71.
16. Bernstein EF, Lee J, Lowery J, et al. Treatment of spider veins with the 595 nm pulsed-dye laser. J Am Acad Dermatol 1998;39(5 Pt 1):746-50.
17. Bernstein EF. The new-generation, high-energy 595 nm, long pulse-duration pulsed-dye laser effectively removes spider veins of the lower-extremity. Lasers Surg Med 2007;39:218-24.
18. Kono T, Yamaki T, Ercocen AR, Fujiwara O, Nozaki M. Treatment of leg veins UIT the long pulse dye laser using variable pulse durations and energy fluences. Lasers Surg Med 2004;35:62-7.
19. Tanghetti E, Sherr E. Treatment of telangiectasia using the multi-pass technique with the extended pulse width, pulsed dye laser (Cynosure V-Star). J Cosmet Laser Ther 2003;5:71-5.
20. McDaniel DH, Ash K, Lord J, Newman J, Adrian RM, Zukowski M. Laser therapy of spider leg veins: clinical evaluation of a new long pulsed alexandrite laser. Dermatol Surg 1999;25:52-8.
21. Kauvar AN, Lou WW. Pulsed alexandrite laser for the treatment of leg telangiectasia and reticular veins. Arch Dermatol 2000;136:1371-5.
22. Eremia S, Li C, Umar SH. A side-by-side comparative study of 1064 nm Nd:YAG, 810 nm diode and 755 nm alexandrite lasers for treatment of 0.3-3 mm leg veins. Dermatol Surg 2002;28:224-30.
23. Trelles MA, Allones I, Alvarez J, et al. The 800-nm diode laser in the treatment of leg veins: assessment at 6 months. JAAD 2005;54:282-9.
24. Wollina U, Konad H, Schmidt W-D, Haroske G, Astafeva LG, Fassler D. Response of spider leg veins to pulsed diode laser (810 nm): a clinical, histological and remission spectroscopy study. J Cosmet Laser Ther 2003;5:154-62.
25. Sadick NS, Trelles MA. A clinical, histological, and computer-based assessment of the polaris LV, combination diode, and radiofrequency system, for leg vein treatment. Lasers Surg Med 2005;36:98-104.
26. Trelles MA, Martin-Vazquez M, Trelles OR. Treatment effects of combined radio-frequency current and a 900 nm diode laser on leg blood vessels. Lasers Surg Med 2006;38:185-95.
27. Omura NE, Dover JS, Arndt KA, Kauvar ANB. Treatment of reticular leg veins with a 1064 nm long-pulsed Nd:YAG laser. J Am Acad Dermatol 2003;48:76-81.
28. Rogachefsky AS, Silapunt S, Goldberg DJ. Nd:YAG Laser (1064 nm) irradiation for lower extremity telangiectases and small reticular veins: efficacy as measured by vessel color and size. Dermatol Surg 2002;28: 220-5.
29. Black JF, Barton JK. Chemical and structural changes in blood undergoing laser photocoagulation. Photochem Photobiol 2004;80: 89-97.
30. Randeberg LL, Bonesronning JH, Dalaker M, Nelson J, Svaasand LO. Methemoglobin formation during laser induced photothermolysis of vascular skin lesions. Lasers Surg Med 2004;34:414-9.
31. Mordon S, Brisot D, Fournier N. Using a “non uniform pulse sequence” can improve selective coagulation with a Nd:YAG laser (1.06 microm) thanks to methemoglobin absorption: a clinical study on blue leg veins. Lasers Surg Med 2003;32:160-70.
32. Baumler W, Ulrich H, Haiti A, Landthaler M, Shafirstein G. Optimal parameters for the treatment of leg veins using Nd:YAG lasers at 1064 nm. Br J Dermatol 2006;155:364-71.
33. Parlette EC, Groff WF, Kinshella MJ, Domankevitz Y, O’Neill J, Ross EV. Optimal pulse durations for the treatment of leg telangiectasias with a neodymium YAG laser. Lasers Surg Med 2006;38:98-105.
34. Ross EV, Domankevitz Y. Laser leg vein treatment: a brief overview. J Cosmet Laser Ther 2003;5:192-7.
35. Lupton JR, Alster TS, Romero P. Clinical comparison of sclerotherapy versus long-pulsed Nd:YAG laser treatment for lower extremity telangiectases. Dermatol Surg 2002;28:694-7.
36. Levy JL, Berwald C. Treatment of vascular abnormalities with a long-pulse diode at 980 nm. J Cosmet Laser Ther 2004;6:217-21.
37. Coles CM, Werner RS, Zelickson BD. Comparative pilot study evaluating the treatment of leg veins with a long pulse Nd:YAG laser and sclerotherapy. Lasers Surg Med 2002;30:154-9.
38. Baumler W, Vural E, Landthaler M, Muzzi F, Shafirstein G. The effects of intense pulsed light (IPL) on blood vessels investigated by mathematical modeling. Lasers Surg Med 2007;39:132-9.
39. Sadick NS. Laser and intense pulsed light therapy for the esthetic treatment of lower extremity veins. Am J Clin Dermatol 2003;4:545-54.
40. Goldman MP, Eckhouse S. Photothermal sclerosis of leg veins. Dermatol Surg 1996;22:323-30.
41. Schroeter CA, Wilder D, Reineke T, Thuerlimann W, Raulin C, Neumann HAM. Clinical significance of an intense, pulsed light source on leg telangiectasias of up to 1 mm diameter. Eur J Dermatol 1997;7: 38-42.
42. Weiss RA, Goldman MP, Weiss MA. Treatment of poikiloderma of civatte with an intense pulsed light source. Dermatol Surg 2000;26: 823-8.
43. Weiss RA. Evaluation of the venous system by Doppler ultrasound and photoplethysmography or light reflection rheography before sclerotherapy. Semin Dermatol 1993;12:78-87.
44. Sadick NS. Manual of sclerotherapy. Baltimore: Lippincott Williams & Williams; 2000.
45. Bone C. Tratamiento endoluminal de las varices con laser de diodo studio preliminary. Rev Patol Vasc 1999;5:35-46.
46. Krivda MS. The latest approaches to treating leg veins. Skin Aging 2005;13:72-7.
47. van der Stricht J, van Oppens C. Should varices be treated before or after pregnancy? Phlebologie 1991;44:321-6.
48. Sumner DS. Venous dynamics: varicosities. Clin Obstet Gynecol 1981; 24:743.
49. Bouissou H, Julian M, Pieraggi M, Louge L. Vein morphology. Phlebologie 1988;3(Suppl 1):1-8.
50. Widmer LK. Peripheral venous disorders: prevalence and sociomedical importance observations in 4529 apparently healthy persons. Basle Study III. Bern: Hans Huber; 1978.