Endovenous laser ablation for the treatment of lower extremity chronic venous disease

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INTRODUCTION — Endovenous laser ablation (EVLA) is a percutaneous technique that uses laser energy to ablate incompetent superficial veins. The axial veins are the primary target for this therapy and include the great saphenous vein (GSV), small saphenous vein (SSV), and accessory saphenous veins (ASVs). This topic will review the indications, perioperative care and outcomes of EVLA.

Alternative approaches to the treatment of chronic venous disease using laser and light therapy, radiofrequency energy, liquid and foam sclerotherapy, and open surgical management are discussed elsewhere.

●(See "Overview and management of lower extremity chronic venous disease".)

●(See "Laser and light therapy of lower extremity telangiectasias, reticular veins and small varicose veins".)

●(See "Radiofrequency ablation for the treatment of lower extremity chronic venous disease".)

●(See "Liquid, foam, and glue sclerotherapy techniques for the treatment of lower extremity veins".)

●(See "Open surgical techniques for lower extremity vein ablation".)

INDICATIONS — The indications for EVLA are the same as for other vein ablation therapies including radiofrequency ablation, sclerotherapy and open surgical stripping. Venous ablation is indicated in patients with symptoms and signs of venous disease that persist in spite of a trial of medical management, and documented reflux in the target vein (ie, retrograde flow >0.5 seconds). The patient’s symptoms should directly relate to the incompetent veins being treated. (See "Overview and management of lower extremity chronic venous disease", section on 'Initial conservative management' and "Medical management of lower extremity chronic venous disease".)

CONTRAINDICATIONS — EVLA is contraindicated in patients with acute deep vein thrombosis and in pregnant patients, due to the risk of developing a new DVT [1]. We prefer to wait a minimum of six weeks after delivery in pregnant patients before performing EVLA.

Patients with congenital venous abnormalities (eg, Klippel Trenaunay syndrome, Parkes Weber syndrome) should generally not undergo ablation of major superficial veins. Selected patients may, however, benefit from localized
management of symptomatic segments (sclerotherapy, stab phlebectomy). (See "Open surgical techniques for lower extremity vein ablation", section on 'Ambulatory phlebectomy'.)

Relative contraindications to EVLA for a given vein segment include:

● Chronic or recurrent phlebitis in the target vein, since formation of synechiae in the vein can prevent passage of the laser sheath.

● Severe tortuosity in which passage of the device may not be possible.

● Target veins that are not at least 1 cm deep to the skin dermis after tumescent anesthesia is administered. Ablation of veins closer to the skin may lead to skin burns.

● Target great saphenous vein (GSV) segments that are aneurysmal (>2.5 cm in diameter). These may have a greater risk of failure. (See 'Anatomic failure' below.)

Patients with lower extremity ulceration should be assessed to ensure the adequacy of the arterial circulation, since patients with chronic venous disease complicated with ulceration can have coexistent peripheral artery disease. If the arterial circulation is found to be inadequate for wound healing, the arterial disease should be addressed prior to treating the venous disease. (See "Clinical features and diagnosis of lower extremity peripheral artery disease".)

ANATOMY
Venous anatomy — The veins of the lower extremity are divided into superficial, perforating, and deep veins (figure 1A-B). The superficial veins lie superficial to the muscle fascia. The perforating veins cross the fascia and connect the superficial veins to the deep veins that are located beneath the fascia. The deep veins are never treated with endovenous therapies.

● Great saphenous vein — The great saphenous vein (GSV) is one of the two main superficial veins in the lower extremity (figure 1A-B). It is the longest vein in the body and originates on the medial aspect of the leg. It crosses anterior to the medial malleolus and ascends along the medial aspect of the leg and thigh. Just below the inguinal ligament, it enters the fossa ovalis and terminates in the common femoral vein at the saphenofemoral junction.

● Small saphenous vein — The small saphenous vein (SSV) originates laterally from the dorsal venous arch of the foot, crosses posterior to the lateral malleolus, and ascends in the posterior calf (figure 1A-B). In the upper calf, the SSV passes through the deep muscle fascia and terminates in the popliteal vein; however, the anatomy at the saphenopopliteal junction is variable (figure 2) [2-5]. The SSV can join a superficial cephalad extension in the posterior thigh (vein of Giacomini), connect to both the popliteal vein and the posterior thigh vein, or join the popliteal vein with no major tributaries near the junction (figure 2). Anatomic variations in the SSV have implications for SSV ablation [5]. (See 'Small saphenous ablation' below.)

● Accessory saphenous veins — The accessory saphenous veins (ASVs) are any of several venous segments that ascend parallel to the GSV. Anterior ASVs are located anteriorly, and can be found in the thigh or leg (figure 1A-B) [6].

● Perforator veins — The normal flow in the perforating veins is from superficial to deep; however, many perforators demonstrate bidirectional flow. When the perforating veins are incompetent, flow is from deep to superficial. The most clinically significant perforating veins connect the posterior arch vein to the posterior tibial vein. These veins, termed posterior tibial perforators, were formerly known as Cockett’s perforators.

Saphenous nerve — The saphenous nerve is the largest cutaneous branch of the femoral nerve. It lies near the superficial femoral artery in the thigh, exiting the adductor canal traveling deep to the sartorius muscle (figure 3A-B). It typically becomes superficial after it emerges medially between the tendons of the sartorius and gracilis muscles at the
knee and then travels adjacent to the GSV. The saphenous nerve provides sensory innervation to the medial aspect of the leg. The saphenous nerve is adherent to the saphenous vein in the distal third of the calf [7].

Sural nerve — The sural nerve is formed by the medial and lateral sural cutaneous nerves, which join at approximately the level of the distal one-third of the gastrocnemius muscles (figure 4). It lies near the SSV and passes below the lateral malleolus. The sural nerve provides cutaneous innervation to the posterior leg and lateral foot.

MECHANISM OF ACTION AND LASER DEVICES — Lasers emit a single, coherent wavelength of light (figure 5). Laser therapy of venous structures is based upon the concept of selective photothermolysis (ie, selective thermal confinement of light-induced damage) [8]. The wavelength of light is chosen based upon the chromophore (the part of a molecule responsible for its color) of the target tissue. Vein wall injury is mediated directly by absorption of photon energy by the vein wall (thermal radiation) and indirectly by thermal convection from steam bubbles, and thermal conduction from heated blood [8-11]. (See "Basic principles of medical lasers").

Commercially available devices for EVLA are manufactured by Angiodynamics (810 nm and 1470 nm diode lasers), Dornier MedTech (940 nm diode laser), Sciton (1319 nm Nd:YAG laser), CoolTouch (1320 nm Nd:YAG laser), and Biolitec (1470 nm diode laser). The wavelength of laser may impact outcomes [12-14].

Some have speculated that the use of a bare laser fiber may lead to inhomogeneous vein wall destruction due to a tendency of the tip to become located eccentrically within the vein. A flared tip (Tulip Tip, Tobrix), designed to center the laser and promote more homogeneous heating, is commercially available in Europe, but not in the United States. One trial using this device noted reduced postoperative ecchymosis and pain; however, the differences demonstrated were small and likely not clinically significant [15]. Similarly, mild differences in post-procedure pain were identified using the 1470 nm laser catheters with a radial fiber compared with the bare-tip fiber [16].

PREOPERATIVE EVALUATION AND PREPARATION — The diagnostic evaluation is performed by taking a careful history, performing a physical exam, and obtaining noninvasive vascular laboratory studies. A venous duplex ultrasound of the affected lower extremity should evaluate the deep veins, great saphenous vein (GSV), accessory saphenous veins (ASVs), if present, and small small saphenous vein (SSV) for patency as well as the presence of reflux. The clinical evaluation of lower extremity chronic venous insufficiency is discussed elsewhere. (See "Clinical manifestations of lower extremity chronic venous disease" and "Diagnostic evaluation of chronic venous insufficiency").

Medications — Aspirin, antiplatelet agents, and nonsteroidal antiinflammatory drugs (NSAIDs) are sometimes discontinued to limit postoperative bruising, but is not necessary. (See 'Bruising/hematoma' below.)

For patients who are therapeutically anticoagulated, cessation of anticoagulation is not necessary prior to EVLA. Perioperative anticoagulation with low molecular weight heparin or warfarin does not appear to affect the success of endovenous closure [17-20]. Patients requiring warfarin following stroke who are undergoing endovenous ablation procedures should continue warfarin, as suggested by the American Academy of Neurology, given the low risk of bleeding associated with the EVLA [21].

If cessation is selected, warfarin may be temporarily discontinued or bridging anticoagulation initiated with heparin or low molecular weight heparin. (See "Perioperative management of patients receiving anticoagulants", section on 'Deciding whether to interrupt anticoagulation'.)

Prophylactic antibiotics — Antibiotic prophylaxis is generally not needed prior to EVLA. However, when EVLA is combined with vein excision, antibiotics should be administered to decrease the risk of surgical site infection [22]. (See "Antimicrobial prophylaxis for prevention of surgical site infection in adults", section on 'Antimicrobial prophylaxis'.)
Planning supplemental procedures — Options to manage significant symptomatic varicose veins include microphlebectomy or sclerotherapy at the same time as EVLA, or deferred treatment. The main advantage of performing EVLA with concomitant treatment is a reduction in the overall treatment time. The advantage of waiting four to six weeks following EVLA is that the residual veins tend to be smaller and may be more amenable to injection sclerotherapy instead of phlebectomy, and in many cases, no further treatment is needed. This effect is due to reduced venous pressure in the tributaries of the EVLA-ablated saphenous vein. Large varicose veins and those located on the thigh are less likely to respond to elimination of reflux, and we prefer to manage these concurrently with the ablation procedure.

One trial randomly assigned 50 patients to EVLA with concomitant phlebectomy or EVLA with sequential phlebectomy [23]. The concomitant treatment group required longer operative times, fewer subsequent procedures (1 of 25 versus 16 of 25), and a trend towards longer time to return to work (10 versus 3 days). The concomitant treatment group also had a lower HRQOL at six weeks and three months; however, no differences in HRQOL were seen at one year and remained equal at five years [24]. It is important to note that in the sequential treatment group, a supplemental procedure was not needed in one-third of the patients. Similarly, a retrospective study of 80 patients treated with EVLA alone found that supplemental treatment was needed in only 42 percent of patients [25].

A comprehensive review of over 300 limbs treated with EVLA and sequential phlebectomy identified anatomic and clinical factors associated with lack of regression of superficial varicosities following EVLA [26]. CEAP (Clinical, Etiologic, Anatomic, Pathophysiologic) classification did not affect the need for secondary procedures. An increased likelihood of requiring secondary procedures was found for enlarged (>6 mm) GSV in the distal thigh, patients with clusters of large (>6 mm) diameter varicosities, and patients in whom the cosmetic appearance was very important. These patients might benefit from a combined EVLA and phlebectomy performed as a single stage procedure.

Patient counseling — The indications for the procedure, alternatives (eg, continued medical management, vein stripping), risks, and benefits (relief of symptoms attributable to the venous insufficiency) should be discussed with the patient. The patient is informed that:

- Unforeseen anatomic issues may result in failure (ie, the inability to perform an endovenous procedure) in which case the patient may need to be rescheduled for a repeat or alternative procedure. (See 'Anatomic failure' below.)

- In spite of successful technical application of the endovenous device, non-closure of the vein or late vein recanalization can occur and may be more common in larger diameter veins. In these cases, EVLA may be repeated or an alternative procedure performed. (See 'Anatomic failure' below.)

- Associated varicosities that have not been treated at the time of the EVLA should become less noticeable, but may not completely disappear. Supplemental procedures may be needed to achieve the desired cosmetic result [27,28]. Whether simultaneous versus delayed sclerotherapy or phlebectomy is being performed should be understood prior to the procedure. (See 'Planning supplemental procedures' above.)

- Other risks of the procedure can include bleeding, infection, phlebitis, deep vein thrombosis, and cutaneous nerve injury leading to numbness or paresthesias. (See 'Complications' below.)

- Alternatives to endovenous laser ablation include no therapy, compression therapy, sclerotherapy, radiofrequency ablation, or surgical removal of refluxing superficial veins. (See "Medical management of lower extremity chronic venous disease" and "Liquid, foam, and glue sclerotherapy techniques for the treatment of lower extremity veins" and
"Radiofrequency ablation for the treatment of lower extremity chronic venous disease" and "Open surgical techniques for lower extremity vein ablation."

Compression stockings — Patients are prescribed Class II or higher compression stockings (thigh-high or pantyhose), which they should obtain prior to the day of the scheduled procedure (table 1). (See "Compression therapy for the treatment of chronic venous insufficiency", section on 'Compression hosiery'.)

Schedule duplex appointment — A prescheduled appointment should be made for follow-up duplex examination two to three days after EVLA to assess for deep vein thrombosis. (See 'Postoperative duplex ultrasound' below.)

Vein mapping/marking — On the day of the procedure, the veins to be ablated can be marked (ie, marked with indelible ink) with duplex ultrasound to aid in the administration of tumescent anesthesia, but it is generally not necessary. (See 'Anatomic failure' below and 'Postoperative duplex ultrasound' below.)

PROCEDURE — EVLA can be performed in a clinic or office or other outpatient surgery setting with oral diazepam and local anesthesia with or without supplemental venous procedures [29]. If moderate sedation is used, a nurse should be dedicated to monitoring the patient’s level of consciousness, heart rate, blood pressure, and oxygen saturation. Local tumescent anesthesia is always required, even if the patient undergoes general anesthesia in an operating room.

Preparation

Equipment

● Duplex ultrasound machine – The procedure can be performed with a portable ultrasound machine (gray scale imaging); however, color duplex imaging with a vascular probe is ideal.

● Laser generator – Check the machine for proper functioning; calibrate if necessary.

● Tilt table – The ability to adjust the patient’s position between Trendelenburg and reverse Trendelenburg is highly desirable. Alternatively, a venous tourniquet can be used to assist engorgement of the vein during access, and an Esmarch bandage can be used to compress the vein.

● Pump for tumescent anesthesia (eg, Klein pump) – The pump is used to infuse tumescent anesthesia but is not essential. If a Klein pump is not available, the tumescent anesthesia can be injected by hand.

Medications

● Local anesthetic for puncture site: 1% lidocaine without epinephrine. The addition of bicarbonate may help diminish the pain of injection.

● Tumescent anesthetic (a mixture of saline, epinephrine, bicarbonate and lidocaine for subcutaneous injection) should be ordered from the pharmacy in advance and mixed just prior to the procedure.

Materials

● Preparation materials: skin prep, sterile gloves

● Draping materials: sterile drape, bag for foot

● Tubing for tumescent

● Echogenic 21 gauge micropuncture needle
• 10 mL syringe with 16 to 20 gauge needle to draw up anesthetic, 25 to 30 gauge needle to inject

• Micropuncture sheath kit: micropuncture wire (0.035”), 4F device dilator/sheath

• Additional guidewires: glidewire (0.018”)

• Wound dressing: Gauze and elastic wrap or thigh-high elastic stocking with gauze pads, or adhesive strips or bandages

General technique — EVLA is performed according to the manufacturer’s recommendations. The general technique is described below.

Prepare and position the patient — The patient is positioned supine for treatment of the GSV or ASVs. The prone position is preferred for treatment of the SSV but it can be successfully treated in the supine position. The leg should be prepped to include the saphenofemoral junction (for treatment of the GSV) or the sapheno-popliteal junction (for treatment of the SSV) since these areas must be imaged with ultrasound.

Place the device sheath — It is important that the patient is relaxed and well hydrated. The patient is placed in reverse Trendelenburg position to engorge the target vein, a position that facilitates venous access. Using ultrasound guidance, a micropuncture cannula is introduced into the vein near the knee for GSV ablation or near the ankle for SSV ablation and a long guidewire advanced toward the saphenofemoral junction (or sapheno-popliteal junction).

On occasion, the vein may develop spasm during venipuncture. Carefully selecting an accessible portion of the vein and successfully obtaining access upon the first attempt greatly reduce the risk of vasospasm. Placement of a venous tourniquet just proximal to the vein or the application of 2% nitroglycerin paste over the vein may break the spasm and prevent the need for a second venipuncture. Alternatively, a cutoff to access the vein can be performed.

Difficulty advancing the wire or the sheath into the proximal vein may be encountered in the presence of a tortuous vein, venous aneurysms or vein segments that are sclerotic or occluded. Severely tortuous vein segments cannot be treated, though this should be recognized in advance on preoperative duplex ultrasound. (See 'Contraindications' above and 'Vein mapping/marking' above.)

Mildly tortuous venous segments, sclerotic segments and venous aneurysms can usually be crossed with manual manipulation of the overlying skin or by using a hydrophilic wire (eg, glidewire). Segmental occlusions can be managed with two treatments administered through two separate sheaths placed proximal and distal to the occlusion.

Position the catheter — A 4 French laser sheath is advanced over the wire and positioned in the proximal vein. Correct catheter position is critical to reduce the risk of deep vein thrombosis. The tip of the laser should be placed at least 2 cm below the saphenofemoral (or sapheno-popliteal) junction and the position confirmed with ultrasound. Ideally, the catheter tip should be just distal to at least one tributary vein to ensure continued flow in the more proximal vein. Be aware of arteries in close proximity to the vein to minimize the possibility of creating an arteriovenous fistula [30]. Examples include a deep external pudendal artery coursing posterior to the proximal GSV and sural artery branches in close proximity to the SSV or perforators.

Patients with variant SSV anatomy with no tributaries to the proximal SSV may be at a higher risk for deep vein thrombosis [3].(See 'Venous anatomy' above and 'Small saphenous ablation' below.)

Once the sheath is in place, the patient should be placed in the Trendelenburg position. This serves to empty and allow better contact of the laser catheter to the wall of the vein, which may help reduce postprocedure pain.

The laser sheath is back out to expose the tip of the laser catheter. The position of the tip of the catheter should be rechecked with ultrasound and correct placement confirmed. This is a critical portion of the procedure. Sometimes air
bubbles in the gel or hair around the groin can reduce visibility. Also, imaging the catheter in obese patients with deep veins can be a challenge. If technical issues obscure the catheter, and its position cannot be positively ascertained, the procedure should be aborted and an alternative procedure performed (eg, vein stripping, sclerotherapy).

Instill tumescent anesthetic — With ultrasound imaging, an echogenic micropuncture needle is used to inject tumescent anesthesia into the tissue surrounding the vein. Tumestuent anesthesia has several important functions including:

● Providing anesthesia during EVLA
● Facilitating contact of the vein wall with the laser tip
● Deepening the vein relative to the skin to protect the skin from damage during laser treatment
● Acting as a heat sink to protect surrounding tissues, especially sensory nerves, from the thermal damage during laser treatment

After completion of the tumescent anesthesia, it is important to confirm with ultrasound that a halo of tumescent anesthetic surrounds the catheter, especially in the region of the saphenofemoral junction, and to ensure that the catheter and vein are at least 1 cm deep to the skin.

Ablate the vein — After adequate tumescent anesthesia has been delivered, the vein is ready for treatment. The catheter is slowly pulled back at an initial rate of 1 mm every second for the first 10 cm of treatment length. Thereafter, the catheter can be pulled back 2 to 3 mm every second. A slow, steady pullback provides even heating of the entire vein segment and minimizes the chance of vein perforation.

Perform completion ultrasound — Following completion of the procedure, ultrasound examination of the common femoral vein (or popliteal vein for treatment of the SSV) is performed to confirm patency and exclude thrombus. Closure of the treated vein is confirmed. The vein should appear thickened (ie, hyperechoic doughnut) with thrombus in its lumen with no identifiable venous flow.

Perform supplemental procedures — Following successful closure of the target veins, the extremity is evaluated for any significant residual varicose veins, which can be managed with phlebectomy or sclerotherapy depending upon their size or operator preference. (See 'Planning supplemental procedures' above.)

When we identify large varicose tributaries to the ablated vein, we will selectively perform stab phlebectomy or sclerotherapy at the time of the EVLA to prevent superficial thrombophlebitis. (See 'Superficial thrombophlebitis' below.)

Specific anatomic considerations — The technical aspects of the EVLA procedure vary with the anatomic site. Venous anatomy is described above. (See 'Venous anatomy' above.)

Great saphenous ablation — Treating the distal saphenous vein is not necessary because the majority of patients obtain adequate relief of their venous symptoms without extending the ablation below the mid-calf. Doing so may increase the risk of saphenous nerve injury. (See 'Nerve injury' below.)

● One trial randomly assigned 65 patients with above and below-knee GSV reflux into three groups: above knee GSV EVLA, mid-calf to groin (extended) GSV EVLA, or above knee EVLA plus below knee GSV foam sclerotherapy [31]. All patients experienced significant improvements in symptoms; the extended EVLA group had the highest patient satisfaction and the lowest requirement for subsequent sclerotherapy, and the below-knee foam sclerotherapy group was a close second.
The same group of investigators evaluated 69 below-knee GSV segments with duplex ultrasound six weeks following above-knee GSV EVLA, and found 59 percent had no or minimal reflux [32]. All patients experienced significant improvement in symptoms, but patients with persistent reflux in the below-knee GSV more often required sclerotherapy for residual symptomatic varicose veins.

Clinical failure following EVLA of the GSV can be due to large refluxing accessory saphenous tributaries (figure 1A-B). As a result, we prefer to treat ASVs that demonstrate significant reflux at the same time as GSV ablation. The second sheath needs to be placed in the ASV prior to instillation of tumescent anesthesia. We treat the GSV first, since it is usually the larger vein.

Small saphenous ablation — Anatomic variation in the sapheno-popliteal junction is common [5]. In about 30 percent of patients, the SSV does not communicate with the popliteal vein; rather, it drains cephalad continuing as the superficial posterior thigh vein (vein of Giacomini). In some individuals, the SSV drains into the popliteal vein directly with no significant tributaries. These patients have a higher risk of developing deep venous thrombosis with SSV endovenous ablation [3]. (See 'Deep vein thrombosis' below.)

Puncture of the SSV at the midcalf level was found in one trial of 60 patients to lead to less postoperative paresthesias without affecting the success of closure at six months follow up, compared with puncture at the ankle level [33]. (See 'Nerve injury' below.)

Perforator ablation — Although there are special catheters designed to treat incompetent perforating veins (eg, Venacure®), there are no studies showing that treatment of incompetent perforating veins leads to faster ulcer healing or a decreased incidence of ulcer recurrence. Studies that have evaluated patients undergoing treatment for incompetent perforating veins almost universally include patients with combined treatment of an incompetent GSV, making analysis of the clinical utility of adding the treatment of perforating veins difficult to determine.

**FOLLOW-UP CARE**

Pain management — EVLA is generally well tolerated and controlled with over-the-counter pain medications (eg, acetaminophen). In one study, 85 percent of patients complained of no or minimal pain [34]. Moderate to severe pain is experienced in 4 to 9 percent of patients [35,36]. Extensive concurrent vein excision may require stronger analgesics (eg, codeine). Pain gradually resolves with time and is improved by wearing compression stockings. (See 'Compression stockings' above.)

Nonsteroidal antiinflammatory drugs can be added in patients who develop a significant phlebitic reaction. An ice pack can also be applied to the affected areas for comfort. (See 'Superficial thrombophlebitis' below.)

**Patient instructions**

Clinical symptoms that should prompt the patient to call their physician include:

- Swelling or excessive pain that is not relieved with the prescribed pain medications may be a symptom of deep vein thrombosis.

- Numbness, tingling, coolness or discoloration of the toes of the treated extremity. The compression bandages/stockings may be too tight and need to be removed.

Routine instructions include:

- Ambulate normally and take short (20 minute) leisure walks three times daily.
• Avoid prolonged standing and sitting; when seated, elevate the treated extremity.

• Refrain from strenuous cardiovascular activities (eg, heavy lifting, exercise) for one to two weeks; thereafter, resume normal activities.

• Resume normal job duties within three to four days; however, jobs requiring prolonged standing and/or heavy lifting may require additional time off.

• Maintain the postoperative dressing and elastic bandages/stockings until the postoperative duplex examination, which should occur within two to three days following the procedure.

• Reinforce any areas of bleeding that occur through the dressing, but patients should call their physician if excessive bleeding occurs. This is more commonly associated with vein excisions performed at the same time as the endovenous ablation.

• Wear thigh-high graded compression stockings day and night for one to two weeks following the procedure. However, the optimal compression regimen following EVLA has not been well studied and differing types and duration have been used successfully [37].

• Do not be alarmed if there is a pulling sensation or tightness over the treated vein. This is due to the scarring of the vein, which adheres to the surrounding tissues. Gentle stretching exercises in the area of the treated vein may be helpful. For great saphenous ablation, stretching the inner thigh muscle is accomplished by sitting on the floor with the feet pressed together and leaning forward. For the SSV, stretching the vein is accomplished by leaning forward against a wall with the affected leg placed behind the hips with the foot flat on the floor.

Postoperative duplex ultrasound — All patients should undergo duplex ultrasound within two to three days following the procedure to rule out deep vein thrombosis (DVT) [35,38]. The main purpose of the postoperative duplex study is to carefully evaluate the proximal extent of the ablated vein for thrombus and to determine whether any thrombus extends into the deep veins. Thrombus extending from the saphenous vein into the proximal deep vein cephalad to the level of the ablation can lead to DVT, although this is uncommon [35]. This process has been termed endovenous heat-induced thrombus (EHIT). If the initial ultrasound demonstrates no thrombus in the deep vein, repeat ultrasound is not required unless the patient develops new symptoms. Thrombus within the deep vein is treated accordingly. (See 'Deep vein thrombosis' below and "Overview of the treatment of lower extremity deep vein thrombosis (DVT)".)

In a retrospective review of 312 perioperative vein mappings, patients with valvular incompetence at the saphenofemoral junction or a large proximal GSV diameter had a significantly increased risk of developing EHIT [39]. Patients who developed EHIT had a mean great saphenous diameter of 13.1 mm and 11 percent had saphenofemoral junction incompetence. In comparison, those who did not develop EHIT had a mean diameter of 8.4 and only 0.44 percent had saphenofemoral junction incompetence. A review of over 4000 EVLA treatments supports the notion that increasing the distance of the laser tip from the saphenofemoral junction reduces the risk of EHIT [40]. In this study there was a trend toward a decreased incidence of EHIT when the tip of the catheter was ≥2.5 cm compared with 2 cm from the junction (2.3 versus 1.3 percent).

However, a separate review that included 519 great or anterior saphenous vein EVLA procedures did not identify vein diameter, short distance of the catheter tip to saphenofemoral junction, type of endovenous ablation (radiofrequency versus EVLA), concomitant treatments (sclerotherapy, phlebectomy), or perioperative anticoagulation as risk factors for EHIT [41]. Rather, on multivariate analysis, male gender and Caprini thrombosis risk factor assessment score (table 2) were the only significant risk factors.
A classification system has been proposed (based upon studies of endovenous radiofrequency ablation) to provide an accurate description of the level of proximal great saphenous thrombus due to EHIT for the purpose of guiding clinical therapy and further research [42]. The classification scheme is as follows; levels I, II, and III represent superficial venous thrombosis (SVT) while levels IV, V, and VI represent deep venous thrombosis (DVT):

- **Level I:** Thrombus below the superficial epigastric vein
- **Level II:** Thrombus up to the origin of the superficial epigastric vein
- **Level III:** Thrombus up to but not into the common femoral vein
- **Level IV:** Thrombus bulging into the common femoral vein but not adherent to the wall of the common femoral vein
- **Level V:** Thrombus extending into the common femoral vein and adherent to the adjacent wall
- **Level VI:** Occlusive thrombus of the common femoral vein

If the initial ultrasound demonstrates no thrombus in the deep vein, repeat ultrasound is not required unless the patient develops new symptoms.

In a review of over 500 EVLA procedures, EHIT occurred in 4.9 percent at the saphenofemoral junction, and in 6.3 percent at the saphenopopliteal junction [43]. Among the 25 patients with EHIT at the saphenofemoral junction, three were classified as Level III, and seven as Level IV, all 10 of which were treated with observation. All of the patients with Level III and three of the patients with Level IV EHIT resolved at one week; the other four patients with Level IV resolved between two to seven weeks. Of the 12 patients with Level V EHIT, six were not treated with anticoagulation and all resolved in one week. The other six patients with Level V were treated and the thrombus retracted between two and six weeks. (See 'Superficial thrombophlebitis' below.)

Thrombus within the deep vein is treated accordingly. In the study described above, the three patients with Level VI EHIT were all treated with anticoagulation, and the DVT resolved within six weeks and anticoagulation was discontinued [43]. None of the patients developed a pulmonary embolism (See 'Deep vein thrombosis' below.)

Physician follow-up — In the absence of symptoms, the patient should be seen in the office within six weeks of the procedure to re-evaluate the clinical symptoms/signs of venous disease and determine the need and timing for any possible supplemental procedures. (See 'Planning supplemental procedures' above.)

**COMPLICATIONS** — Although EVLA is generally well tolerated, a variety of complications can occur. The most important are nerve injury and deep vein thrombosis (DVT). These and other complications, such as skin bruising/hematoma, skin burns, and superficial thrombophlebitis are discussed below.

A review from the National Surgical Quality Improvement Program (NSQIP) included 1786 patients undergoing EVLA [44]. Surgical site infection was less common for EVLA compared with vein stripping (0.5 versus 1.4 percent); however, DVT occurred more frequent with EVLA (1.6 versus 0.8 percent).

**Bruising/hematoma** — Approximately 60 percent of patients treated with EVLA have ecchymosis to some extent [45]. The median time to resolution is about two weeks. The incidence of bruising has been reported to be lower [34,45], as well as higher [46], compared with vein stripping. More severe bruising is probably related to perforation of the treated vein, which may be due to contact of the laser tip with the vein wall.

**Hematoma** occurs in 1 to 5 percent of patients undergoing EVLA of the GSV [29,35,46]. One trial that randomly assigned 200 patients to EVLA or GSV ligation and stripping found significantly more hematomas in patients who underwent GSV
ligation and stripping (12 versus 5) [46]. Another trial found that the size of hematomas that occurred was significantly smaller at one week for EVLA compared with surgical stripping [45].

Skin burns — Skin burns are a preventable complication and should be a rare occurrence following EVLA. The infusion of adequate amounts of tumescent anesthesia should be performed to ensure that the treated vein is more than 1 cm below the skin surface. Investigators performing EVLA without tumescent anesthesia have reported an incidence of skin burns of about 5 percent [13]. (See 'Instill tumescent anesthetic' above.)

Superficial thrombophlebitis — A mild superficial thrombophlebitis is anticipated along the course of the ablated vein [47]. In addition, varicose veins that are in direct communication with the treated vein may thrombose, or collapse and scar down. The reported incidence of symptomatic phlebitis following EVLA ranges from 0 to 5.2 percent and does not appear to be related to whether or not concomitant phlebectomy was performed [13,34-36,45].

Superficial thrombophlebitis is managed conservatively. Thrombosed veins that are painful and tender can be treated with cold compresses and nonsteroidal antiinflammatory drugs (eg, ibuprofen). (See "Superficial thrombophlebitis of the lower extremity", section on 'Treatment'.)

More significant signs or symptoms of pain or edema warrant ultrasound examination to evaluate for thrombus extending from the saphenous vein into the common femoral vein. Superficial venous thrombosis with thrombus up to but not into the common femoral vein due to endovenous heat-induced thrombosis (EHIT) is thought to be more benign than spontaneous thrombus in this location. A repeat ultrasound should be performed within a week. Patients with thrombus in the proximal saphenous vein due to EHIT may or may not be anticoagulated while awaiting repeat ultrasound [42]. (See 'Postoperative duplex ultrasound' above.)

Deep vein thrombosis — Thromboembolic complications following EVLA are uncommon. The incidence varies in the literature depending upon whether routine duplex ultrasound is performed within two to three days following EVLA [48,49]. Some large series of EVLA with duplex ultrasound follow-up have noted 0 percent incidence of DVT [34,36,45,49], while others report an incidence of 0.9 to 2.3 percent [35,42,48,50]. The author’s experience is consistent with the latter reports. Pulmonary embolism and stroke in a patient with a patent foramen ovale have also been reported following EVLA [51,52].

Some of the variation in the incidence of DVT may also be related to how well the saphenofemoral junction is examined with duplex ultrasound following EVLA. An experienced technician should perform the examination. (See 'Postoperative duplex ultrasound' above.)

The majority of DVT following EVLA appears to be related to extension of clot from thrombus induced in the ablated vein and is more commonly partially occlusive (level IV or V). Direct thermal injury to the deep veins due to catheter tip malposition can also occur. Patients diagnosed with DVT are anticoagulated and a follow-up duplex ultrasound should be obtained in four to five days.

In many cases, thrombus contraction occurs with the thrombus no longer apparent within the common femoral vein, at which point anticoagulation may be discontinued. DVT due to endovenous therapies usually resolves within two weeks following initiation of anticoagulation, which is faster than with spontaneous DVT [35,42]. In our experience, most resolve within a week. Patients whose thrombus extension into the deep vein persists are treated with anticoagulation using warfarin and a repeat ultrasound in two to three weeks. If thrombus contraction has occurred, the patient can discontinue anticoagulation.

Patients with persistent thrombus extension and those with occlusive deep venous thrombosis are managed according to standard protocols. (See "Overview of the treatment of lower extremity deep vein thrombosis (DVT)").
Nerve injury — Sensory abnormalities due to nerve injury following EVLA occur with a reported incidence ranging between <1 to 7 percent [36,49,51]. Symptoms of saphenous nerve injury include pain or numbness along the medial aspect of the calf or lateral foot and occasionally a feeling of pressure or tightness around the knee or ankle. These symptoms typically resolve four to six weeks after EVLA.

Because of the close proximity of the saphenous nerve and vein in the distal calf, saphenous nerve injury may be more likely when the endovenous sheath is placed below the level of the mid-calf, due to the adherence of the saphenous nerve to the saphenous vein in the distal third of the calf [7]. (See 'Saphenous nerve' above.)

Adequate tumescent anesthesia is probably the most important factor in preventing nerve injuries. In an observational study of patients undergoing EVLA without tumescent anesthesia, the rate of paresthesia was much higher at 36 percent compared with other studies in which tumescent anesthesia was used [13].

Due to the risk for saphenous nerve injury, surgical stripping of the saphenous vein in the mid- to distal calf is no longer recommended. For similar reasons, we prefer not to extend ablation of the GSV below the mid- to upper-calf. (See 'Great saphenous ablation' above.)

Technical complications

Anatomic failure — Following saphenous ablation, duplex ultrasound can show procedural failure, but some of these patients have clinical improvement that is maintained long-term. Anatomic failure is a useful term to distinguish these patients from those with clinical failure (ie, recurrent clinical symptoms and/or varicose veins). Anatomic failure has been classified as follows [53]:

• Nonocclusion – Type I anatomic failure refers to veins that failed to occlude initially and never occlude during follow-up.

• Recanalization – Type II anatomic failure refers to veins that were initially confirmed to be occluded but later recanalized, either partially or completely.

• Groin reflux – Type III anatomic failure refers to the situation in which the vein trunk was occluded but reflux persisted in the groin region. This type of failure often involves an ASV.

Other issues — Other technical complications have been described in case reports.

Arteriovenous fistula formation is rare, but has been reported [30]. The popliteal fossa is felt to be at increased risk for this complication following SSV ablation due to the proximity of the sural arteries to the vein and may be related to errant placement of the tumescent needle [54,55]. (See "Acquired arteriovenous fistula of the lower extremity".)

Although uncommon, a retained foreign body from a broken laser catheter tip has also been reported [51]. Care in placement of the tumescent needle minimizes the potential of this complication. Device components should be examined carefully after they are removed from the patient to ensure their integrity. If there is any question about the possible loss of a device, radiographs should be obtained.

VEIN CLOSURE RATES

Great saphenous vein — Initial technical and short-term success for treatment of the great saphenous vein (GSV) ranges from 90 to 100 percent [45,56-60]. A systematic review and meta-analysis of the various modalities for the treatment of lower extremity chronic venous disease including endovenous therapies found that the pooled success rate for EVLA at three years was significantly higher compared with radiofrequency ablation, vein excision, or sclerotherapy (94 versus 84, 77, and 78 percent, respectively) [56].
Failure of endovenous laser ablation for the GSV appears to depend upon the diameter of the vein:

- In one study of 500 patients treated with EVLA, 98 percent of GSV were successfully closed on the initial postprocedure duplex ultrasound. After four years, the closure rate had decreased to 97 percent. All failures occurred in patients with a saphenofemoral junction >11 mm, or a GSV diameter >8 mm [36].

- In another study, initial success for EVLA of the GSV was found to be 95 percent. In the successfully treated veins, the average maximum vein diameter was 11 mm, whereas, for the failures, the mean maximum vein diameter was 21 mm [61].

Other reports demonstrate equal effectiveness for treating very large GSVs compared with smaller veins:

- One study found no significant differences in the failure rates of EVLA in 732 patients with large diameter veins >10 mm (4.5 versus 3.4 percent) compared with smaller diameter veins [62]. Large veins constituted 12 percent of the total veins treated and 1 percent of the veins had a diameter >20 mm. The vein obliteration rate in the largest veins (20 to 24 mm) was 100 percent.

- In another study of 38 consecutive ablations, 20 GSVs measured >1 cm in diameter and four measured >2 cm in diameter [63]. Successful ablation was achieved in 100 percent of veins, independent of vein diameter.

Accessory and small saphenous veins — Short-term results of EVLA of the accessory saphenous vein (ASVs) and small saphenous vein (SSV) have shown closure rates equivalent to GSV EVLA with minimal complications [64-69]. The primary success rates are 87 to 98 percent for the anterior ASV, and 91 to 93 percent for the SSV [62,66,70,71]. In a trial that randomly assigned 106 patients with unilateral, primary SSV reflux to EVLA or surgery, reflux was eliminated in significantly more patients treated with EVLA compared with surgery (96 versus 72 percent) [72]. The high failure rate in the surgery group was primarily due to an inability to strip the SSV because of tortuosity or the vein breakage. In spite of the increased incidence of persistent axial reflux in the SSV, the symptomatic improvement was the same in both groups and remained the same after two years.

Perforating veins — Studies are not available looking at long-term success or clinical outcomes (eg, ulcer healing) of laser perforator ablation. Feasibility studies have shown that EVLA is technically possible and appears safe [50,73,74]. A trial that randomly assigned 69 patients to EVLA of incompetent thigh perforators draining into the GSV, or EVLA of the GSV found significantly lower technical success rates for perforator ablation compared with great saphenous ablation (77 versus 100 percent) [74]. Both groups experienced similar clinical success and both groups had a single recannulization of the GSV between one week and one month.

CLINICAL OUTCOMES — Although vein stripping has been the standard for the management of lower extremity varicose veins and venous reflux, randomized trials have found that minimally-invasive therapies, including radiofrequency ablation (RFA), EVLA, and sclerotherapy, provide similar or improved clinical outcomes compared with GSV ligation and stripping [56,75,76].

Measures of venous symptom severity (eg, Venous Clinical Severity Score, Aberdeen Varicose Vein Symptom Score), and quality of life scores (eg, Medical Outcomes Study Short Form-36) have been used to compare outcomes of EVLA and GSV ligation and stripping in several clinical trials. No significant differences in these scores were found at short-term (one to three months) [45,57,77], or longer-term (two [46], and five year) follow-up [78].

A single trial has compared EVLA with radiofrequency ablation. Patients diagnosed with saphenous vein reflux were randomly assigned to EVLA using 980 nm wavelength laser (64 patients) or radiofrequency ablation using VNUS ClosureFAST (67 patients) [79]. No significant differences were found in the outcomes measures listed above at six weeks follow-up.
One small trial that randomly assigned 20 patients with bilateral symptomatic GSV reflux to EVLA for one leg and vein stripping for the other leg found that 70 percent of the patients preferred EVLA [34]. Another trial randomly assigned 449 patients to either ligation of the saphenofemoral junction and stripping of the GSV, ligation of the saphenofemoral junction and EVLA of the GSV, and EVLA of the GSV alone. Clinical varicose vein recurrence rates were the same for all three treatments over the six-year follow-up period [80]. Another trial compared EVLA with ultrasound-guided foam sclerotherapy, or surgical stripping [81]. EVLA was associated with fewer complications and a trend for improved quality of life (eg, primarily prolonged bruising, tenderness, staining, hematoma).

Return to normal activities — The time to return to normal activities or return to work is variable among the available clinical trials. One trial of 99 patients found a decreased time to return to normal activity (2 versus 7 days) and return to work (4 versus 17 days) for EVLA compared with GSV ligation and stripping [57].

On the other hand, two trials involving 200 and 121 patients found no significant differences in return to normal activity or work (average, 7 days) [46,77]. Yet another trial found a longer time until return to work for EVLA compared with GSV ligation and stripping (20 versus 14 days) [45].

Postoperative pain — As with return to normal activities, EVLA is associated with variable levels of pain compared with GSV ligation and stripping. Trials have found more pain [82], less pain [45], or no difference in pain [34,46,77], experienced by patients undergoing EVLA.

A trial that compared EVLA with radiofrequency ablation found more postoperative pain following EVLA (mean pain score 34 versus 22) and more analgesic use [79]. The average numbers of analgesic tablets for EVLA versus radiofrequency ablation were 14 versus 9 tablets by postoperative day 3, and 36 versus 20 tablets by postoperative day 10.

Compared with open surgery, EVLA appears to be better tolerated. A trial that randomly assigned 280 patients to open surgery or EVLA found significant improvements in Venous Clinical Severity Score (VCSS) and Aberdeen Varicose Vein Questionnaire for both groups after treatment [83]. Periprocedural quality of life measures were maintained following EVLA, but surgical patients experienced more pain and disability with a significant decline in five of eight Short Form 36 (SF-36®) domains leading to a significant difference between the two treatments in pain scores. As a result, surgical patients took longer to return to work and normal activity compared with patients undergoing EVLA (14 versus 4 days).

Similar results have been noted for SSV EVLA. In a trial comparing SSV EVLA with surgery, significantly less postoperative pain occurred after EVLA allowing an earlier return to work and normal function [84]. Fewer minor sensory disturbances occurred in those who underwent EVLA compared with surgery (7.5 versus 26.4 percent). However, both groups demonstrated similar improvements in Venous Clinical Severity Score and quality of life.

Vein recurrence — Varicose vein recurrence is reported with long-term follow-up at rates that are similar to radiofrequency ablation [59]. In large retrospective studies, varicose vein recurrence has been reported to occur in 7 to 14 percent of patients long-term (two to seven years) following EVLA [66,85].

Randomized trials have found a varying incidence of recurrent varicose veins following EVLA when compared with GSV ligation and stripping.

- In a trial of 449 patients who underwent surgical stripping or EVLA (with or without ligation of the saphenofemoral junction), freedom from clinical recurrence was 60 percent at five years [80]. The clinical recurrence rates were the same for surgical stripping and EVLA.

- Similarly, in a trial of 121 patients involving 137 legs, freedom from clinical recurrence was 60 percent at five years [78].
A trial involving 280 patients found a significantly lower incidence of varicose vein recurrence in patients treated with EVLA (4 versus 20 percent) compared with those treated with surgery [86]. The authors noted that over half of the recurrences in the great saphenous stripping group were due to reflux in the below-knee GSV that was not treated. The second most common cause for recurrence was neovascularization at the saphenofemoral junction, a process that was much less common after EVLA.

In another trial that randomly assigned 400 patients to high ligation and stripping or EVLA, recurrent varicose veins were observed in both groups but the difference was not significant (16.2 versus 23.1 percent) [87]. However, duplex-detected saphenofemoral reflux was significantly more frequent after EVLA (17.8 versus 1.3 percent).

Cost — Cost analysis of minimally invasive venous ablation methods have varied.

One trial evaluated differences in cost between EVLA and GSV ligation and stripping and found no significant differences between these procedures [77]. Total costs of each procedure, including lost wages and equipment, were calculated for 121 patients. The total cost for EVLA was $4347 (€ 3396) and for GSV ligation and stripping, $3948 (€ 3084).

Another trial used a Markov model to estimate costs of foam sclerotherapy, EVLA, and surgical stripping. Costs were significantly decreased for EVLA compared with surgical stripping, but were more than sclerotherapy [88]. However, because of overall greater improvements in health-related quality of life, EVLA was judged to be the more cost-effective treatment.

INFORMATION FOR PATIENTS — UpToDate offers two types of patient education materials, “The Basics” and “Beyond the Basics.” The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on “patient info” and the keyword(s) of interest.)

• Basics topic (see "Patient information: Vein ablation (The Basics)"

SUMMARY AND RECOMMENDATIONS

• Endovenous laser ablation (EVLA) is a minimally-invasive percutaneous technique using laser energy to ablate incompetent superficial veins. EVLA is used primarily to treat venous insufficiency of the axial veins (ie, great, small, or accessory saphenous veins). (See 'Introduction' above and "Overview and management of lower extremity chronic venous disease", section on 'Vein ablation therapies'.)

• Candidates for endovenous laser ablation are patients with persistent symptoms/signs of venous disease after a trial of medical therapy plus documented reflux (ie, retrograde flow >0.5 second duration) as a source of their symptoms. (See 'Indications' above.)

• Endovenous laser ablation is typically performed in an office or ambulatory surgery setting with local anesthesia and anxiolytics. If concurrent vein excision is performed, moderate sedation is preferred. (See 'Procedure' above.)
For great saphenous vein (GSV) ablation, we suggest not extending EVLA below the mid-calf to minimize the risk of saphenous nerve injury (Grade 2C). Symptoms of saphenous nerve injury may include pain or numbness along the medial aspect of the calf or lateral foot. These symptoms typically resolve within four to six weeks of the procedure. (See 'Place the device sheath' above and 'Nerve injury' above.)

Some degree of pain and/or bruising is common following EVLA and a mild superficial phlebitis is expected. Pain associated with EVLA is usually controlled with over-the-counter pain medications (eg, acetaminophen). Pain gradually resolves over time and is improved by wearing compression stockings. Extensive concurrent vein excision may require stronger analgesics (eg, codeine). (See 'Pain management' above and 'Patient instructions' above and 'Compression stockings' above.)

Duplex ultrasound should be performed within two to three days of the procedure to evaluate for deep vein thrombosis. If the initial ultrasound demonstrates no thrombus in the deep vein, repeat ultrasound is not required unless the patient develops new symptoms. Patients found to have thrombus within the common femoral vein are treated for deep venous thrombosis. (See 'Postoperative duplex ultrasound' above and 'Superficial thrombophlebitis' above and 'Deep vein thrombosis' above.)

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