Ultrasound Guided (US) Endovenous Laser Ablation (EVLA) of lower limb varicose veins: "how to do"

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Learning objectives

1. Illustrate the EVLA procedure.
2. Show how to obtain a good US-visualization of veins in order to monitor the ablation procedure and to avoid possible complications.
3. Describe the post-operative management
Background

The veins complex of the lower limb can be divided in two compartments separated by the muscular fascia: deep (deep veins) and superficial (superficial veins). Veins of the same compartment are connected by the communicating veins, while veins of deep and superficial compartments are connected by the perforating veins that pass through the muscular fascia.

The main veins of the superficial venous system are the great and the small saphenous veins, that drain the skin and subcutaneous tissue of the lower extremity.

The great saphenous vein arises from the medial marginal vein, at the level of medial malleolus, it runs up the medial surface of the leg and, after passing the posteromedial side of the knee, it ascends the thigh in an antero-medial position. The great saphenous vein reaches the region of the femoral triangle and, at this level, it perforates the deep fascia and it joins the common femoral vein at the sapheno-femoral junction. The great saphenous vein is located in a subcompartment of the superficial compartment, named "saphenous venous compartment"; this subcompartment is bounded deeply by the muscular fascia and superficially by the saphenous fascia, and by US-imaging it can be easily visualized in the thigh by its characteristic "Egyptian eye" shape (Fig 1).

The small saphenous vein arises from the lateral marginal vein, posteriorly to the lateral malleolus; it passes laterally to the Achilles tendon and it courses posteriorly in the leg to reach the upper calf where, by perforating the crural fascia, it enters the popliteal fossa between the two heads of the gastrocnemius muscles and it joins the popliteal vein.

The great and the small saphenous veins insufficiency is a common condition that may lead to the occurrence of varices.

Normally, the flow of the blood in the veins against gravity is ensured by a complex system of valves and by the muscle contractions. When valves becomes incompetent or a muscle pump dysfunction arises, the veins may become unable to pump enough blood back to the heart, blood flows backward and it accumulates in the veins (venous reflux or venous insufficiency).

Blood pooling causes increased pressure from the deep to the superficial leg veins that results in the development of varices.

Varicose veins are defined as veins visible under the skin, with diameter greater than 3-4 mm, that appear swollen, palpable and tortuous and most commonly localized in the legs (Fig 2).
More than 80% of varicose veins visible on the legs are caused by superficial venous insufficiency of the great saphenous vein and the sapheno-femoral junction is the main point of reflux in most patients with superficial venous insufficiency.

The etiology of the venous insufficiency is unknown, however in the majority of case this condition can be considered a primary (or hereditary) disease. Secondary risk factors linked to an higher risk of having varicose veins are: age, obesity, jobs that involve a long-period standing or sitting, sedentary lifestyle, pregnancy, thrombosis or thrombo-phlebitis.

Clinically, the venous reflux is often asymptomatic or paucisymptomatic; subjectuve symptoms may include pain, soreness, ache, heaviness, throbbing and restless leg.

Varicose veins are a manifestation of a mild-severe chronic venous insufficiency. According to the CEAP classification system (that give a classification of the chronic venous disorder based on Clinical, Etiology, Anatomy and Pathophysiology), there are six different clinical class depending on the severity of the objective symptoms (clinical signs): C0) No visible or palpable signs; C1) Telangiectasies or reticular veins (diameter < 3mm); C2) Varicose veins (diameter >3 mm); C3) Edema; C4) Changes in skin and subcutaneous tissue; C5) Healed ulcer; C6) Active ulcer.

The varicose veins and, more generally, the chronic venous insufficiency treatment is nowadays represented by the EndoVenous Laser Ablation (EVLA). As reported in literature, since the first application of EVLA by Carlos Bonè in 1999, it has widely established as a therapeutic option to the traditional stripping surgery, representing the most common interventional procedure used in the saphenous veins reflux treatment.

The key to EVLA success is being an effective, safe, painless and fast treatment.

The procedure consists of the introduction, after local anesthesia, of the laser fiber through the skin into the vein, under US-guidance. The laser heats the vein walls, causing shrinking and vein collapse.

The laser technology uses the laser energy that, depending on its wavelength, is absorbed by different tissue target. The most recent laser has an high wavelength (1470nm) that means its primary target is the intracellular water of vein walls and the water content in blood (and not the haemoglobin). This results in minimal invasiveness and safety, because it has been demonstrated a lower energy necessity to achieve a complete vein occlusion and a reduced risk of complications compared to the low wavelength endovenous laser systems.

A further technological development has led to the radial laser fiber that applies energy around the 360 degrees of the vein wall, achieving an homogeneous energy release and
a lower energy level needed. Compared with the frontal emission fibers, the radial fiber avoids vein perforations and damage to the surrounding tissue, and it minimizes the risk of complications and adverse effects.

The EVLA procedure is well-accepted by patients because it does not require general anaesthesia and so it can be performed in an ambulatory setting.

US-imaging has an important role in the whole treatment planning, from the pre-operative diagnosis of venous insufficiency, during the ablation procedure as a mandatory guidance in order to introduce needle and laser fibers and to monitor vessel shrinking, to the post-operative follow-up.
Fig. 1: US-imaging shows the typical "Egyptian Eye" aspect of the saphenous compartment. Arrow, Great Saphenous Vein (GSV); arrowhead, deep muscular fascia; black arrowhead, saphenous fascia

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Fig. 2: Clinical presentation of lower limbs varicose veins. Note the swollen and tortuous aspect of varices.

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Imaging findings OR Procedure details

We will provide a "how to do" guide of the EVLA procedure highlighting the following steps:

- Pre-treatment US-evaluation of patient lower limb veins with detailed scan planes
- Sterile field setting and patient arrangement
- US-guided laser fiber insertion procedure
- Endovenous laser ablation
- Post-operative management and follow-up

Pre-treatment US-evaluation of patient lower limb veins with detailed scan planes

Patient with symptoms and clinical findings of superficial venous insufficiency of the lower limb veins is evaluated by US-imaging in order to obtain a precise anatomic and flow mapping of the venous system prior to planning the endovenous laser ablation treatment.

The goals of the US-examination are to identify all incompetent superficial veins and to determine whether they are responsible for the patient's clinical problem.

The US-evaluation by a 7-10 Mhz linear probe should be performed with patient in a standing position and the leg under examination turned outward.

With the patient in front of the examiner, the sapheno-femoral junction at the level of the groin and the great saphenous vein from its junction down along the tight are evaluated. Next, patient is turned backward to examine the small saphenous vein and its sapheno-popliteal junction at the level of the popliteal fossa. A complete US-examination includes the evaluation of the femoral and popliteal veins near their saphenous junctions to exclude significant deep vein obstruction.

Both morphology and flow of the veins must be studied. In particular, a relationship to varicose veins, an enlargement of the vein diameter and the presence of a retrograde flow should always be excluded (Fig. 3).

Normally, the vein is 4 mm in diameter. Veins >7 mm are pathological (Fig. 4).

The evaluation of the veins with Color-Doppler and Power-Doppler is performed to visualize the direction of flow; venous reflux is documented when, after a quick
compression and release of the extremity, the antegrade flow is followed by a retrograde flow that lasts for more than 2 seconds (Fig. 5).

**Sterile field setting and patient arrangement**

Despite the minimal invasiveness of the interventional procedure, the patient must be informed about all the possible contraindications related to the procedure. Although the complication rate associated with this procedure is extremely low, patients should be aware that complications occurrence cannot be ruled out entirely. The subjects that must be clearly explained to the patient are the following:

- Pain/burning sensation during the procedure
- Pain/soreness after the procedure and need to take drugs for pain relief (Nonsteroidal anti-inflammatory drugs)
- Potential risk of hematoma, edema, infections, skin burns and small scars
- Rare risk of thrombosis in proximity of the saphenofemoral junction

After receiving these information, the patient must formally agree to the procedure by providing both verbal and written informed consent.

Preliminary preparation of the equipment is necessary (Fig 6):

- 7-12 Mhz linear probe
- Sterile gauzes
- Sterile ultrasound gel
- Sterile ultrasound probe cover
- Sterile towels
- Sterile gloves
- Coloured disinfectant (e.g. 7.5%-10% iodopovidone solution)
- Uncoloured disinfectant (e.g. banzalkoniumchloridine solution + alcohol ethylic)
- 3/4 syringes (60 ml)
- 1 syringe (10 ml)
- 2 needles (18 G and 25 G)
- Laser System (ELVeS Radial 2ring Laser System (1470nm), BioLitec®)
- Kit: Laser fiber, introducer sheath, dilator, J-shaped tip guide wire, cannula needle (18 G)
- Local anesthetic (Lidocaine 2%)
- Tumescent anesthesia solution (500 ml saline, 20 ml Lidoc. 2%, 2 ml Sodium-Bicarbonate)
- Lance sterile scalpel (size 11)
- Bulldog clamp
- Ice pack
A pre-treatment evaluation of patient physiological parameters (heart rate, blood pressure, oxygen saturation) is mandatory also in ambulatory setting, followed by an intraoperative monitoring.

The US-guided interventional procedure must be performed in aseptic environment in order to avoid any risk of contamination by infectious organisms (bacteria, fungi, viruses) or other microorganisms. Disinfection of instruments and use of sterile covers are mandatory before starting the procedure.

The patient is placed horizontal on the table, in supine position for the treatment of great saphenous vein reflux with the tight slightly externally rotated, whereas in prone position for the small saphenous vein treatment with feet hanging off of the table. If the target vein appears small when the patient lies down, a reverse Trendelenburg position may be useful. An accurate disinfection of patient's skin and the isolation of the operative field placing sterile towels on patient are necessary to ensure asepsis.

**US-guided laser fiber insertion procedure**

The entire course of target vein is visualized with a 7-12 Mhz linear probe and a local intradermal injection of a small amount of anesthesia is administered at the site of the needle insertion.

Under US-guidance, a 18 G needle is used to cannulate the vein with an in-plane approach, using either a cranio-caudal or a caudo-cranial access, according to the case; as the cannula needle enters, the vein blood will be seen in the flashback chamber (Fig. 7).

By using a biopsy needle guide kit, the cannulation of the vein begins easier and the vein vasospasm can be avoided.

After inserting the introducer needle, the guide wire is placed through it into the vein pulling the needle back. The guide wire can be easily recognized by US-probe as a linear hyperechoic image within the vein; in particular, the US-guidance allows to check the correct intravenous guide wire placement within the vein along its entire course (Fig. 8).

The introducer sheath and the dilator are then inserted over the guide wire into the vein, through a small incision in the skin using alance sterile scalpel (size 11).

After removing the guide wire, the laser fiber is inserted into the introducer sheath and it is advanced under US-guidance to the level of the groin (2 cm below the sapheno-femoral
junction, just short of its point of entry into the deep-vein system, next to the epigastric vein) or the popliteal fossa (at the level of the sapheno-popliteal junction), depending on the vein treated. The catheter is withdrawn and the correct position of the laser fiber tip is confirmed by US-control, using then the bulldog clamp as a landmark (Fig. 9).

**Endovenous laser ablation**

Before starting with the laser energy emission, the optical fiber is connected to the laser system and a tumescent local anesthesia is performed.

Three or four 60 ml syringes filled by an anesthetic solution, composed of 500 ml saline, 20 ml lidocaine 2%, 2 ml sodium bicarbonate, are used to create a cushion of water around the vein to protect the perivenous tissue; under US-guidance, tumescent solution is injected around the vein along its entire course (perivascular infiltration), in a sub-fascial location, so that it insulates the heat from damaging adjacent structures, as nerves and skin, and it provides local anesthesia for pain control (Fig 10).

The laser system is set by choosing the adequate dose of energy to be issued, calculated in units of joules per centimeter of the vein (Linear Endovenous Energy Density or LEED). The laser energy (J/cm) is the result of the vein diameter (mm) multiplied by 10; this value is divided by two to obtain the energy required removing the laser fiber for a distance of 5 mm.

The endovenous laser ablation is performed delivering laser energy through the fiber while it is pulled down along the vein under US-control. The laser fiber is withdrawn by around 5 mm between each pulse of laser energy corresponding at a sound signal; moreover, a red light under the skin emitted by the optical fiber tip can help to follow the fiber extraction (Fig. 11 and Fig. 12).

Being the diameter of the vein different along its length, the released energy must be decreased as the vein becomes more superficial and so narrower.

**Post-operative management and follow-up**

After complete removal of the laser fiber, a US-control of the treated vein is necessary.

The patient skin is cleaned with sterile gauzes and saline solution, then a plaster is placed over the needle insertion site. A compression bandage is placed on the treated leg for 2-5 days.

Locally apply ice over the treated area and use of analgesic can be useful.
Patient physiological parameters are re-evaluated at the end of the procedure to monitor the after-effects of anesthesia.

The complete treatment takes about 30-45 minutes and patient can return to normal activities immediately.

US-examination is essential to evaluate treatment success following the endovenous laser ablation, demonstrated by a vein fibrosis, a reduction in vein diameter, thickening of vein walls and no flow showed by Color-Doppler exam (Fig. 13).

Two days follow-up after the interventional procedure and a long-term evaluation (4-5 months) are obtained.
Fig. 3: US-evaluation of lower limb veins. US scan shows a subcutaneous varicose vein.

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Fig. 4: US-evaluation of lower limb veins (short- and long-axis scan). Note the enlarged vein diameter.

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**Fig. 5:** US-evaluation of lower limb veins. Power-Doppler imaging shows the retrograde venous flow.

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Fig. 6: A well-organized tray containing the required materials as syringes, needles, anesthetic solution, sterile US gel, sterile US probe cover, sterile tissues, gloves, biopsy needle guide, sterile bulldog clamp, lance sterile scalpel

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Fig. 7: US-guidance well shows the vein cannulation. Asterisk, GSV; black arrowhead, cannula needle; arrowhead, deep muscular fascia

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**Fig. 8:** US-imaging of the guide wire (black arrowheads) easily recognized as a linear hyperechoic image along the vein course. Note the typical artifact below the guide.

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Fig. 9: Laser fiber tip below the sapheno-femoral junction. Asterisk, sapheno-femoral junction; arrowhead, laser fiber; star, epigastric vein; circle, common femoral vein (CFV)

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Fig. 10: Tumescent local anesthesia. A tumescent anesthetic solution is injected all around the vein, along its entire course.

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**Fig. 11:** Endovenous laser ablation. The laser radiation heats the vein walls and it creates a typical signal with the Color-Doppler imaging. Asterisk, Great Saphenous Vein (GSV)

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Fig. 12: Endovenous laser ablation

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**Fig. 13:** Post-treatment US-evaluation shows the collapse of the insufficient vein, that appears fibrotic and reduced in diameter.

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Conclusion

US-guided EVLA of lower limb varicose veins is an effective treatment that leads a good clinical outcome.

It is a minimally invasive and safe interventional procedure, related to a low risk of complications.

US-guided EVLA does not require general anesthesia, so it can be performed in an ambulatory setting, increasing patient comfort and resulting in a faster and cheaper treatment compared to the traditional surgery.

EVLA is almost painless and it is a well-accepted treatment option in patients with superficial venous insufficiency.
References