https://doi.org/10.33472/AFJBS.6.2.2024.372-383

African Journal of Biological Sciences

Research Paper Open Access

An Overview about Endovenous Ablation Techniques

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Article History

Volume 6, Issue 2, April 2024

Received:19 April 2024

Accepted: 30 April 2024

Published: 16 May 2024

doi: 10.33472/AFJBS.6.2.2024.372-383

Abstract: Background: Varicose veins are twisted, dilated veins most commonly located on the lower extremities. Varicose veins are subcutaneous veins dilated to at least 3 mm in diameter when measured with the patient in an upright position. They are part of a continuum of chronic venous disorders ranging from fine telangiectasias, also called spider veins, (less than 1 mm in diameter) that present in 43% of men and 55% of women and reticular veins (1 to 3 mm in diameter) to chronic venous insufficiency, which may include edema, hyperpigmentation, and venous ulcers. Chronic venous disease is most commonly described using the CEAP (clinical, etiologic, anatomic, pathophysiologic) classification system. Varicose veins are present in 30% to 60% of adults and increase in incidence with age. Endovenous ablation techniques are minimally invasive procedures used in the treatment of varicose veins. These techniques involve the application of thermal or chemical energy to close off and seal the affected veins. This technique has gained popularity in recent years as a highly effective and less invasive alternative to traditional surgical methods for managing varicose veins. Endovenous ablation involves the use of thermal or chemical energy to close off and seal the affected veins from within, thereby redirecting blood flow to healthier veins. By targeting the diseased veins directly, these techniques minimize the need for surgical incisions and promote faster recovery with fewer complications. It's important to note that the choice of endovenous ablation technique depends on various factors, including the patient's individual characteristics, the location and size of the varicose veins, and the expertise of the treating physician. The selection of the most appropriate technique is typically based on a combination of clinical assessment, patient preference, and physician experience.

Keywords: Endovenous Ablation Techniques

Introduction: Varicose veins are twisted, dilated veins most commonly located on the lower extremities. Varicose veins are subcutaneous veins dilated to at least 3 mm in diameter when measured with the patient in an upright position. They are part of a continuum of chronic venous disorders ranging from fine telangiectasias, also called spider veins, (less than 1 mm in diameter) that present in 43% of men and 55% of women and reticular veins (1 to 3 mm in diameter) to chronic venous insufficiency, which may include edema, hyperpigmentation, and venous ulcers. Chronic venous disease is most commonly described using the CEAP

(clinical, etiologic, anatomic, pathophysiologic) classification system. Varicose veins are present in 30% to 60% of adults and increase in incidence with age **(1).**

Use of the CEAP classification system is important for diagnosis but does not provide guidance for treatment decisions. Treatment options for varicose veins include conservative management and interventional therapies such as thermal ablation, endovenous sclerotherapy, and surgery. The decision to proceed with treatment and the choice of treatment are based on symptoms and patient preferences. Other considerations include cost, potential for complications, availability of resources, insurance reimbursement, and physician training. The presence or absence of deep venous insufficiency and the characteristics of the affected veins can also help guide treatment (**2).**

Over the past 10 years, there has been a significant change in the recommendations for treatment of symptomatic varicose veins. This is in large part because of the lack of evidence supporting the use of compression stockings and the rise of minimally invasive endovascular techniques **(3).**

Interventional treatments

Thermal Ablation. Thermal ablation destroys damaged veins using an external laser or via endovenous catheter using a laser (endovenous laser ablation) or radio waves (radiofrequency ablation). External laser thermal ablation works best for telangiectasias. In this therapy, hemoglobin absorbs laser light leading to thermocoagulation. Endovenous thermal ablation can be used for larger vessels, including the great saphenous vein. Under ultrasound guidance, a laser optical fiber or radiofrequency catheter electrode is inserted into the vein in a distal to proximal direction. Heat from the laser or radio waves coagulates the blood in the vein, resulting in closure of the vein and redirection of blood flow to functional veins **(4).**

Endovenous thermal ablation is performed after a local anesthetic is injected around the vein or after spinal anesthesia. Patients can walk after the procedure and may be discharged home the same day. Patients may return quickly to work and other activities. There is a risk (approximately 7%) of surrounding nerve damage attributed to thermal injury; however, most nerve damage is temporary. Endovenous thermal ablation is recommended as first-line treatment for nonpregnant patients with symptomatic varicose veins and documented valvular reflux, and need not be delayed for a trial of external compression **(5).**

Endovenous Sclerotherapy. Endovenous sclerotherapy involves using ultrasound guidance to inject superficial veins with an agent that causes inflammation of the endothelium, resulting in fibrosis and occlusion in the vein. Sclerotherapy is typically used for small (1 to 3 mm) and medium (3 to 5 mm) veins or to treat recurrent varicose veins after surgery; however, there is not a precise diameter used to make treatment decisions. A needle is inserted into the vein lumen and the sclerosing agent is injected, often with air to create a foam. The foam displaces the blood and reacts with the vascular endothelium, sealing and scarring the vein. A variety of agents may be used, including hypertonic saline, sodium

tetradecyl (Sotradecol), and polidocanol (Varithena). There is no evidence that any of these agents is superior to the others in terms of effectiveness or patient satisfaction **(6).**

Surgery. Ligation and stripping of the great or small saphenous vein has been the standard of care for the treatment of varicose veins after the failure of conservative therapy. However, a growing body of literature does not consistently support surgery as the best interventional treatment option, and the 2013 National Institute for Health and Care Excellence clinical guidelines recommend surgery as third line therapy after endovenous thermal ablation and sclerotherapy **(1).**

Updated surgical techniques use small incisions to reduce scarring, blood loss, and complications and limit removal of the superficial axial veins from the groin to knee. Some of these procedures can be performed under regional or local anesthesia. Ligation and stripping of the great and small saphenous vein are probably the best known procedures. Typically, the vein is divided proximally, a vein stripper is passed distally to an incision made near the knee to access the tip of the stripper. The proximal end of the stripper is secured to the vein and the vein

is then removed as the stripper is pulled distally. Non-saphenous and smaller veins can be removed via phlebectomy, during which a scalpel or large-gauge needle is used to create punctures every 2 to 3 cm along a varicose vein. Segments of the damaged vein are removed using forceps or small hooks **(7).**

Endovenous ablation techniques are minimally invasive procedures used in the treatment of varicose veins. These techniques involve the application of thermal or chemical energy to close off and seal the affected veins. This technique has gained popularity in recent years as a highly effective and less invasive alternative to traditional surgical methods for managing varicose veins **(8).**

Endovenous ablation involves the use of thermal or chemical energy to close off and seal the affected veins from within, thereby redirecting blood flow to healthier veins. By targeting the diseased veins directly, these techniques minimize the need for surgical incisions and promote faster recovery with fewer complications. It's important to note that the choice of endovenous ablation technique depends on various factors, including the patient's individual characteristics, the location and size of the varicose veins, and the expertise of the treating physician. The selection of the most appropriate technique is typically based on a combination of clinical assessment, patient preference, and physician experience **(9).**

The primary goal of endovenous ablation is to achieve vein closure, improving venous flow and reducing symptoms such as pain, swelling, and heaviness in the legs. Additionally, endovenous ablation techniques aim to improve the cosmetic appearance of varicose veins, enhancing patient satisfaction. One of the key advantages of endovenous ablation is its minimally invasive nature. These procedures are typically performed on an outpatient basis, often under local anesthesia, allowing patients to resume their normal activities shortly after the treatment. Compared to traditional surgical stripping,

endovenous ablation techniques offer reduced postoperative pain, scarring, and a faster recovery period **(10).**

Types of Endovenous Ablation

1. **Laser Ablation (Endovenous Laser Ablation - EVLA)**

- **Mechanism of Action:**

Laser ablation works by delivering laser energy directly to the varicose vein, causing thermal damage to the vein wall. The laser energy is absorbed by the hemoglobin in the blood, converting it into heat. The heat generated from the laser energy causes the vein wall to heat up, collapse, and seal shut. Over time, the closed vein is gradually absorbed by the body, and blood flow is redirected to healthier veins **(11).**

- **Procedure Details:**

- Preparation: The patient is typically asked to wear loose-fitting clothing and, in some cases, compression stockings. The specific instructions may vary by healthcare provider.
- Local Anesthesia: The patient is positioned on an examination table, and the affected leg is cleaned and sterilized. Local anesthesia is administered to numb the treatment area. This ensures that the patient is comfortable during the procedure.
- Ultrasound Guidance: An ultrasound machine is used to guide the healthcare provider throughout the procedure. It helps the provider locate the affected vein accurately.
- Catheter Insertion: A thin fiber optic catheter, known as laser fiber, is inserted into the targeted vein through a small incision. The provider carefully navigates the catheter using ultrasound imaging.
- Laser Energy Delivery: Once the catheter is in place, laser energy, usually in the form of a diode laser, is delivered through the fiber optic tip. This

laser energy generates heat, causing the vein wall to contract and seal shut. The catheter is slowly withdrawn along the vein to treat the entire length of the damaged vessel.

- Post-Procedure Care: After the vein has been treated, the catheter is removed. The patient may be required to wear compression stockings immediately after the procedure. This helps reduce swelling and promote healthy blood circulation. Walking and light activities are often encouraged.
- Recovery: Recovery time is relatively short, and most patients can resume their regular activities within a day or two. Strenuous exercise is typically avoided for a few weeks **(12).**

- **Advantages of EVLA:**

- High success rate in treating varicose veins and venous insufficiency.

- Minimally invasive, with a small incision and minimal scarring.
- Reduced risk of complications compared to traditional surgical methods.
- Short recovery time, allowing patients to return to their daily routines quickly **(13).**

2. Radiofrequency Ablation (RFA)

- **Mechanism of Action:**

Radiofrequency ablation uses radiofrequency energy to heat and seal the varicose vein. A radiofrequency catheter is inserted into the vein, and thermal energy is applied to the vein wall. The heat generated from the radiofrequency energy causes the vein wall to collapse and seal shut. Over time, the closed vein is gradually absorbed by the body, and blood flow is rerouted to healthier veins **(14).**

- **Procedure Details:**

- Preparation: The patient is typically asked to wear loose-fitting clothing, and, in some cases, compression stockings may be recommended.
- Local Anesthesia: The patient is positioned on an examination table, and the affected leg is cleaned and sterilized. Local anesthesia is administered to numb the treatment area, ensuring patient comfort.
- Ultrasound Guidance: An ultrasound machine is used to guide the healthcare provider during the procedure. This helps accurately locate the affected vein and navigate the catheter.
- Catheter Insertion: A thin catheter, equipped with a radiofrequency electrode at its tip, is inserted into the targeted vein through a small incision. The provider uses ultrasound imaging to navigate the catheter to the appropriate location.
- Radiofrequency Energy Delivery: Once the catheter is in the correct position, radiofrequency energy is delivered through the electrode tip. This energy generates controlled heat, causing the vein to contract and seal off. The catheter is gradually withdrawn along the length of the vein to treat the entire vessel.
- Post-Procedure Care: After the vein has been treated, the catheter is removed. The patient may be required to wear compression stockings to reduce swelling and support healthy blood flow. Patients are typically encouraged to walk and engage in light activities.
- Recovery: Recovery after RFA is generally quick, and most patients can return to their daily activities within a day or two. Strenuous exercise is typically avoided for a few weeks **(15).**

3. Foam Sclerotherapy (Ultrasound-Guided Foam Sclerotherapy)

- **Mechanism of Action:**

Foam sclerotherapy works by injecting a foam solution into the varicose vein, causing it to collapse and seal off. The foam displaces the blood within the
vein, allowing better contact between the sclerosing agent and the vein wall. The sclerosing agent irritates the vein wall, leading to inflammation and subsequent sealing of the vein. Over time, the closed vein is gradually absorbed by the body, and blood flow is rerouted to healthier veins **(16).**

- **Procedure Details:**

  - Preparation: The patient typically wears loose-fitting clothing, and, in some cases, compression stockings are recommended.
  - Local Anesthesia: The patient is positioned on an examination table, and the treatment area is cleaned and sterilized. Local anesthesia may be administered to numb the targeted area for patient comfort.
  - Ultrasound Guidance: Ultrasound imaging is used to guide the healthcare provider throughout the procedure. It assists in locating the affected vein and ensuring precise placement of the foam solution.
  - Foam Preparation: The provider prepares the foam solution by mixing a sclerosing agent (commonly polidocanol or sodium tetradecyl sulfate) with air or carbon dioxide. The foam is created by agitating the mixture.
  - Foam Injection: Using ultrasound guidance, the provider injects the foam solution directly into the affected vein. The foam displaces the blood within the vein and irritates the vein wall, initiating the closure process.
  - Gentle Compression: After the foam is injected, gentle external pressure may be applied to help distribute the foam within the vein.
  - Post-Procedure Care: Following the procedure, the patient may be required to wear compression stockings to reduce swelling and promote healthy blood circulation. Walking and light activities are typically encouraged.
  - Recovery: Recovery after ultrasound-guided foam sclerotherapy is generally quick, and most patients can return to their regular activities within a day or two. Strenuous exercise is usually avoided for a few weeks **(17).**

4. Mechanochemical Ablation (Clarivein)

Mechanochemical ablation combines mechanical and chemical methods to treat varicose veins. A rotating wire is inserted into the vein, mechanically damaging the inner lining. Simultaneously, a sclerosing agent is infused through the wire to chemically seal the vein. Mechanochemical ablation is a relatively newer technique and may offer advantages in terms of ease of use and reduced procedure time **(18).**

Complications of Endovenous Ablation

- Endovenous ablation techniques for the treatment of varicose veins are generally considered safe and associated with a low risk of complications. However, as with any medical procedure, there are potential complications that can occur. Here are some of the possible complications associated with endovenous ablation **(19)**:
- Pain and Discomfort: Some degree of pain or discomfort is common after the procedure. This can include aching, tenderness, or bruising at the treatment site. Most patients find these symptoms to be mild and temporary, resolving within a few days or weeks.
- Skin Burns or Thermal Injury: Both laser ablation and radiofrequency ablation involve the application of thermal energy to the vein. In rare cases, excessive or improper energy delivery can result in skin burns or thermal injury. Proper technique, patient selection, and careful monitoring during the procedure can minimize this risk.
- Nerve Injury: There is a small risk of nerve injury during endovenous ablation. Nerves in the vicinity of the treated vein can be affected by the procedure, leading to temporary or, rarely, permanent numbness, tingling, or altered sensation in the treated area. This risk can be minimized by meticulous technique and accurate localization of the nerves.
- Deep Vein Thrombosis (DVT): Although the risk is low, endovenous ablation procedures can potentially trigger the formation of blood clots in the deep veins of the legs. This complication, known as deep vein thrombosis (DVT), can be associated with pain, swelling, and warmth in the affected leg. Adequate preoperative evaluation, appropriate patient selection, and postoperative measures such as early ambulation and compression therapy help minimize the risk of DVT.
- Pulmonary Embolism (PE): In rare cases, a blood clot that forms in the deep veins (DVT) can dislodge and travel to the lungs, causing a potentially life-threatening condition called pulmonary embolism. This is a serious complication but is extremely rare in the context of endovenous ablation procedures.
- Superficial Thrombophlebitis: Superficial thrombophlebitis refers to the inflammation and blood clot formation in the superficial veins. It can occur as a result of damage to the vein walls during the procedure. This complication is generally self-limiting and can be managed with conservative measures such as anti-inflammatory medications, compression, and warm compresses.
- Skin Pigmentation Changes: Some patients may experience temporary or permanent skin discoloration in the treated area. This can manifest as

hyperpigmentation (darkening) or hypopigmentation (lightening) of the skin. These changes are usually cosmetic in nature and tend to improve over time.

- Recurrence or Incomplete Closure: In a small percentage of cases, treated veins may reopen or fail to completely close off. This can result in the persistence or recurrence of varicose veins. Proper patient selection, accurate assessment of the venous anatomy, and adherence to appropriate treatment techniques help minimize the risk of recurrence **(19).**

Comparative Analysis of Endovenous Ablation Vs Surgical Stripping of Varicose Veins

Surgical stripping of varicose veins, also known as high ligation and vein stripping, is a surgical procedure performed to treat large or severe varicose veins. It involves the removal or stripping of the affected veins through small incisions in the skin **(20).**

Indications:

Surgical stripping is typically reserved for more severe cases of varicose veins or when minimally invasive treatments are not suitable. It may also be considered when a patient has recurrent varicose veins following prior treatments **(21).Procedure:**

1. Anesthesia: The patient is typically given general anesthesia or regional anesthesia, such as spinal or epidural anesthesia, to ensure they are comfortable and pain-free during the procedure.
2. Incisions: The surgeon makes small incisions over the affected veins. The number and location of the incisions depend on the specific veins being treated.
3. Vein Ligation: The surgeon identifies the target veins and ligates or ties off the veins at their uppermost and lowermost points. This prevents blood from flowing through these veins.
4. Vein Stripping: A special surgical instrument called a vein stripper is inserted through one of the incisions and threaded through the ligation points of the vein. The vein is then grasped by the stripper, and the

instrument is pulled out through another incision, gradually removing the vein from the leg.

5. Closure: Once the targeted veins have been stripped, the incisions are closed with sutures or adhesive strips, and the wounds are dressed with sterile dressings.
6. Recovery: After the procedure, the patient is typically observed in the recovery area for a brief period before being allowed to go home on the same day. Compression stockings or bandages may be applied to aid in healing and

reduce swelling. The patient is generally advised to take it easy for a few days and gradually resume normal activities as directed by the surgeon **(22).**

Potential Complications:

While surgical stripping of varicose veins is generally safe, there are potential complications associated with the procedure, including **(23).:**

- Bleeding: In rare cases, bleeding can occur at the incision sites or from damaged blood vessels during the procedure. Proper surgical technique and meticulous hemostasis (control of bleeding) minimize this risk.
- Infection: There is a small risk of infection at the incision sites. Proper sterile techniques and postoperative wound care help reduce this risk.
- Scarring: The incisions made during the procedure may result in visible scars. However, the incisions are typically small and placed strategically to minimize scarring.
- Nerve Injury: There is a possibility of nerve injury during the procedure. Nerves in the vicinity of the treated veins can be affected, leading to temporary or, rarely, permanent numbness, tingling, or altered sensation in the treated area.
- Deep Vein Thrombosis (DVT) and Pulmonary Embolism (PE): Although rare, surgical procedures carry a small risk of developing blood clots in the deep veins (DVT) or experiencing a clot dislodgment leading to a pulmonary embolism (PE) **(23).**

The EVLA procedure includes the use of a laser, a form of electromagnetic energy, to obtain thermal ablation of the affected vein. Venous closure is achieved by heat-induced shrinkage of the collagen and fibrotic sealing of the lumen of the veins. The vein wall needs to absorb enough energy for the generation of enough heat to get obliterated. In conventional surgery, it includes ligation of the saphenofemoral junction along with stripping of the affected veins. This study compared the outcomes of the patients treated by these two methods by including results from ten randomized controlled trials **(24).**

EVLA, being a newer, less invasive procedure that can be performed under local anesthesia, was thought to have clear-cut superiority to conventional surgery, but the results obtained did not exhibit such superior traits to vouch for EVLA and discard conventional surgery. This study found that the time taken for completion of the procedure between the two groups had no significant difference. Also, the time taken to return to normal activities and the time taken to return to work did not have a significant difference. Faster recovery time is one of the main reasons for preferring minimally invasive procedures, but EVLA showed no such merits over conventional surgery **(25).**

It was found that the technical failure outcome measured at 2 years, and a showed that the ligation and stripping group was four times more likely to be technically successful

compared to EVLA. The main reason for technical failure in the EVLA group is early recanalization. As EVLA works on the principle of achieving vein obliteration by letting the veins absorb enough energy for heat generation, the energy used during the procedure affects the outcome **(26).**

It was found that the energy delivered had a direct effect on recurrence, with the worst results on low-energy delivery compared to high-energy delivery. Early recanalization is avoided when an energy of more than 80 joules per cm is used in the EVLA procedure. Technical failure observed in the surgery group is due to misjudgment of the source of reflux (when USG-guided marking is not done preoperatively) and the breakage of the great saphenous vein during stripping or inadequate stripping. Recurrence in the EVLA group is mainly attributed to technical failure and reflux into the anterior accessory greater saphenous vein, whereas recurrence in the surgery group is attributed to neo-vascularization and technical errors **(21).**

Data from clinical severity score outcomes that assessed the severity of the disease on headings like pain, varicose vein, venous edema, skin pigmentation, inflammation, induration, number of active ulcers, ulcer duration, active ulcer size, and compression therapy was pooled and analyzed. It showed that clinical severity scores at 1 year and 5 years showed no significant difference between the two groups. Postoperative complications like bruising, hematoma, sensory disturbance, infection, and phlebitis were analyzed. This study found that the surgery group had statistically significantly higher complication rates compared to the EVLA group **(27).**

A recent study reported the cost of care, and they showed that the EVLA group had a higher cost of care compared to the surgery group. A cost- effectiveness study concluded that surgical treatment offered robust health benefits at a relatively lower cost than EVLA. Also, the cost of care can go much higher in patients treated with EVLA, as the need for reintervention is greater in this group. The cost of care seems to vary in different regions, as some studies favor the EVLA while others favor conventional surgery **(10).**

EVLA and conventional surgery are both equal in terms of procedural time outcome, time taken to return to normal activities or work, short-term and long-
term recurrences, and clinical severity score. Differences existed in EVLA being more likely to have technical failures, needing more reintervention in the long- term, and having fewer postoperative complications. When choosing a treatment option for a patient, all these factors must be considered. Postoperative complications are less common in EVLA, but its cost and risk of the need for reintervention are the barriers that need to be assessed before choosing it over conventional surgery **(28).**

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