Clinical aspects and indications for endovenous treatments for varicose veins

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Abstract Endovenous laser treatment has been around for more than a decade. A brief history of circumstances that have made this treatment modality possible is provided.

Keywords Endovenous laser treatment · Seldinger technique · History · Duplex ultrasound · Varicose veins

Introduction

At the beginning of this special issue on endovenous techniques in phlebology, it may be necessary to give a short history of circumstances that have made these techniques possible.

Modern man Homo sapiens (130,000 y BC–current) was not the first creature to use bipedalism as a means of locomotion. He has probably evolved from an ape-like ancestor: Australopithecus afarensis (3.7–3 milj. y BC) who probably was the first real bipedal [1]. Its ancestor Ardipithecus or Australopithecus ramidus (pithecus, ape; ramidus, root) (5.8–5.2 milj. y BC) lived in the East African jungle and still combined upright walking with tree climbing [2]. The possibility of bipedal movement made it feasible for these species to move more rapidly and to hunt for small animals that lived outside the jungle. This made it possible for these species to leave the African jungle and migrate to other areas and eventually spread all over the world. This postural change may also have had great implications for the blood column in the thorax and legs and may even be the main reason why varicose veins occur more frequent in man than in animals [3].

Claudius Galen of Pergamum (129–199 AD) who started as a physician to the gladiators and inevitably became an expert on trauma is believed to be the first to use a vascular ligature. He also used a hook to remove varicose veins through several incisions. Eventually, he was appointed as Emperor Marcus Aurelius' personal surgeon [3].

The American surgeon William Lorden Keller (1874–1959) introduced a technique to remove the “internal” saphenous vein in 1905 [4]. He used a wire and multiple incisions and in fact started endovenous treatment for varicose veins. Up to that time, the open procedure as introduced by Friedrich Trendelenburg (1844–1924) was considered to be the standard technique. Later, Mayo, Babcock, and others using various different metal devices have introduced several modifications. In a totally different era and without the help of imaging techniques, diagnosis was made based on patient history, physical examination, and experience, a lot of experience.

The Swedish radiologist Sven-Ivar Seldinger (1921–1998) came up with a simple solution to introduce a radiography catheter into arteries [5]. It made angiography a relatively risk-free intervention, and other fields in medicine soon adopted this technique to safely obtain access to blood vessels and hollow organs.

In 1970, the pencil probe of a “Parkes model 802 Doppler blood flow velocity detector” (Fig. 1) was presented to detect perforating veins [6]. This paved the way for Doppler devices to be used in detecting reflux in patients without using invasive techniques such as phlebography. In the beginning of the 1980s of the last century, a combination echography and Doppler (Duplex ultrasound) was first used to visualize veins preoperatively [7]. Near the end of that century, Duplex ultrasound instruments had become more affordable and become the phlebologist’s main investigative tool.

In 1972, Watts described a thermal coagulation of the “internal” saphenous vein after ligation of the saphenofemoral junction using diathermy [8]. In 1989, Griffith et al. described a new technique of endoluminal diathermy of the long saphenous vein using a bipolar electrode stating that this technique is simple and relatively painless compared with conventional stripping [9].
Somehow, however, both these thermal techniques did not resonate within the surgical (phlebological) community.

Jeffrey Klein, an American dermatologist, started using high volumes of strongly diluted lidocaine solution as an anesthetic in liposuction in the mid-1980s and called it tumescent anesthesia from the Latin verb tumesco, to begin to swell or to swell up. This new technique revolutionized this field in cosmetic surgery because it minimized several risks involved in liposuction under general anesthesia, especially the occurrence of fat emboli [10].

Endovenous laser ablation was invented supposedly following a discussion between Carlos Boné from Spain and Luis Navarro and Robert Min from the USA. Like Watts in 1972, they thought that if sufficient heat was introduced into a vein, it would subsequently coagulate and lose its function. They used tumescent anesthesia for the most part to avoid collateral damage from heat into the surrounding tissues. They published excellent initial results using a diode laser (810 nm): 0\% recanalization in 125 treated limbs after a mean follow-up of 7 months [11]. Currently, the two predominant techniques are endovenous laser ablation (EVLA) using several wavelengths and radiofrequent ablative technique (RFA) using alternating electric fields at radiofrequencies to generate heat.

Clinical aspects

Duplex ultrasound (DUS) is considered to be the “gold standard” reference test for the diagnosis of varicose veins and to assess the severity of venous disease [12]. Investigating patients in the upright position with DUS leads to a full understanding of hemodynamics and anatomy, the so-called “duplex anatomy.” In contrast to the old gold standard phlebography, DUS also visualizes other structures such as fascia. This has changed our definition of the great saphenous vein (GSV), as being that part of the vein that is situated between the muscular and subcutaneous fascia [13]. DUS also addresses the role of reflux in saphenous trunks GSV and small saphenous vein (SSV) on the one hand and the role of the tributaries (such as anterior accessory saphenous vein) on the other (Fig. 2). This will help to determine which treatment option to choose for each individual patient [14].
The importance of DUS as part of the evaluation of patients can be illustrated by two clinical examples. The first example is that of a 74-year-old male patient who had made an appointment because his daughters were concerned about the varicose vein on his upper right leg (Fig. 3). He had no complaints whatsoever. By DUS examination, there was a small reflux (0.4 s) in the GSV and its diameter was approximately 4 mm.

The visual side branch varicosity was removed with ambulatory phlebectomy under local anesthesia. After 6 weeks, DUS examination was repeated and the reflux in the GSV had disappeared. Removal of this varicose vein had restored the hemodynamic disorder in the GSV necessitating no further therapy. Both his daughters and (therefore) also the patient were satisfied about the result.

The second example is that of a 46-year-old female patient who presented herself with venous complaints of heaviness and cramps especially in her right leg. During the day, these complaints worsened and edema formed around her ankle. The visible varicose veins (Fig. 4) were not much of a problem to her, although she would not mind if these could be removed. DUS examination revealed a distally partially incompetent GSV and a connection to the so-called parallel axis proximally anterior axis of the GSV (Fig. 5). Both GSV and parallel axis were treated with EVLA. After 6 weeks, most of the visible varicose veins had disappeared and her complaints.

**Indications**

In contrast to conventional stripping procedures, endovenous ablative techniques are only possible under constant DUS monitoring. In using the Seldinger technique in combination with DUS, physicians can obtain access to veins with very small (e.g., 2 mm) diameters. The laser and RFA catheters used with these techniques are only semiflexible making it impossible to ablate very tortuous varicose veins.

Both great and small saphenous veins are enveloped between the muscular and subcutaneous fascia and are kept in place by the saphenous ligament. Because of their location the majority—if not all—of these veins even when incompetent remain non-tortuous. This enables physicians to insert catheters into these veins. This envelope is also the natural border for the tumescent anesthesia (Fig. 6).

Varicose veins outside the abovementioned envelope, e.g., anterior or posterior accessory vein or even perforator veins can also be treated with endovenous techniques. Extra attention has to be put on the necessary tumescent anesthesia.

**Is time of the essence?**

Having established that an endovenous technique is the therapy of choice for GSV and SSV incompetence, the next question to be answered is: what is reflux?

The National Institute for Health and Clinical Excellence (NICE guidance, UK) nor the German [15] and Dutch Guidelines mention any value for reflux as a threshold for therapy. There is nevertheless a European Consensus Statement that addresses this problem. According to this statement, venous reflux is considered to be retrograde flow in the reverse direction to physiological flow and pathological when lasting...
or more than 0.5 s, though a definitive cutoff for all vein segments has not been agreed upon in the published literature [12]. The American Clinical Practice Guidelines agree with this statement and recommends a cutoff value of 1 s for abnormally reversed flow (reflux) in the femoral and popliteal veins and of 0.5 s for the great saphenous vein, the small saphenous vein, the tibial, deep femoral, and the perforating veins [16].

Do we treat reflux?

Some argue that reflux alone is not enough to decide whether or not to treat saphenous incompetence, and that other parameters have to be taken into consideration. Perhaps venous volume and venous return are more important measurements for venous insufficiency. In an attempt to correlate this volume and GSV incompetence, Navarro and co-workers investigated 112 lower limbs with sapheno-femoral junction and truncal GSV incompetence and concluded that a GSV diameter of 5.5 mm or less predicted the absence of abnormal reflux with a sensitivity of 78 %, a specificity of 87 %, positive and negative predictive values of 78 %, and an accuracy of 82 %. A GSV diameter of 7.3 mm or greater predicted critical reflux (VFI >7 mL/s) with an 80 % sensitivity, an 85 % specificity, and an 84 % accuracy [17]. A recent study has established a relation between clinical severity (as measured with the CEAP classification) and the ambulatory venous pressure measurement. Therefore, clinical signs of venous disease correlate well with the gold standard for determination of the severity of this condition, i.e., ambulatory pressure (Reeder et al.,
Comparison of ambulatory venous pressure measurement and anterior compartment pressure measurement in relation to the CEAP clinical classification of chronic venous disease, submitted for publication.

Anatomical considerations

Venous return in the lower extremity starts at the base of the foot in the plantar plexus. Here, blood is collected in a venous reservoir, a structure also known as Lejar's sponge. From this reservoir, flow is directed outward and valves prevent blood to re-enter after it has been expelled into the superficial venous system. The superficial venous dorsal arch connects the SSV and GSV (Fig. 2). These major branches collect blood from veins in the subcutaneous tissue and direct it toward the deep system at the level of the knee pit and the groin, respectively. From the capillaries into the reticular veins and side branches, blood will flow into the major branches (GSV and SSV).

Between the superficial and the deep system, there are several connecting veins. They are called perforating veins because they perforate the fascia that separates subcutaneous fat and muscles. Early anatomical studies have shown up to 150 perforators in each leg [18]. The blood flow in these perforators is directed inward, making influx into the deep system possible. Valve dysfunction at this level will cause varicose veins that resemble bubble gum under pressure, so-called “blow outs” (Fig. 7). Because of constant pressure, the skin may become extremely thin making it very vulnerable. If one of these blow outs is damaged, even lethal blood loss may be the result.

The next—smaller level—veins are called reticular veins because of their netlike, crisscross distribution in the superficial plane. These veins collect blood from small venules and capillaries, which when incompetent often resemble brushes, hence, brush veins (Fig. 8).

To treat or not to treat?

Over the years, several studies have shown that about 50% of venous ulcers are based on superficial venous insufficiency alone [19, 20]. It is therefore safe to say that restoration of this superficial hemodynamic disturbance will reduce the risk of developing a venous ulcer, which is of great socioeconomic benefit to the society. It is furthermore safe to assume that—as with any valve—incompetence when left untreated will deteriorate over time. We cannot however predict at which rate this deterioration will take place. The decision to treat patients with GSV or SSV incompetence should be based on a tailor-made plan after complete examination of each individual patient. The most important considerations are complaints and the volume of reflux [21].

Phlebology has evolved enormously over the last century. First, from an experience based to an evidence-based diagnostic and therapeutic strategy, and second, from treatment strategies that involve only rigorous surgery and compression therapy for end-stage chronic venous disease into a specialty with sophisticated noninvasive diagnostic tools and minimal invasive techniques for all stages of venous disease.

More than a century after Keller has introduced the stripping operation for varicose veins, the first new development was endovenous laser ablation. Now, with the experience of
more than a decade, endovenous thermal ablation has become the new effective and patient friendly gold standard for the treatment of varicose veins.

References