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Editorial

Dear Readers,

In this new issue,

***Philippe Lemasle** and **Milka Greiner** focus on the use of transcutaneous Doppler ultrasound for the diagnosis of some unusual causes of lower limb varicose veins, such as incompetent intraosseous perforating veins, sciatic nerve varicose veins, and inguinal leak points.*

*Air plethysmography is a small, lightweight device that measures change in calf volume in response to various maneuvers. **Christopher R. Lattimer** and **Erika Mendoza** evaluate the different types of patients with venous disease who need to be investigated with air plethysmography, highlighting the points for best practice.*

***Gabriel Bayona, Miguel Ramírez, Jorge H. Ulloa, Ruben Villarreal, John Fernando Garcia, Rafael Garrido, Luis G. Cadavid,** and J**orge Ulloa-Dominguez** discuss the results of two observational multicenter surveys−ALIADO (quality of life in outpatients with chronic venous disease) and ALIVIO (endovenous ablation of varicose veins)−that were carried out in outpatients with symptomatic chronic venous disease in Colombia in which clinical characteristics, symptoms, and quality of life evolution were evaluated.*

***Marzia Lugli** describes the functioning of intravascular ultrasound and further discusses how the technique can be used to improve venoplasty and stenting of iliac and caval vein obliterations.*

*J**ean-Luc Gerard** presents the role of compression therapy in the treatment of lower limb varicose veins and discusses the necessity of its use after different endovenous treatments, such as sclerotherapy and thermal ablation with perspectives from clinical studies and guidelines.*

Enjoy reading this issue!
Dr H. Pelin Yaltirik
Editorial Manager

Specific criteria of the transcutaneous Doppler ultrasound in unusual causes of lower limb varicose veins

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Abstract

Transcutaneous Doppler ultrasound is the technique of choice to diagnose lower limb varicose veins; it is often the only technique needed. The relative contributions of the great saphenous vein, small saphenous vein, and incompetent perforating veins in the development of superficial venous insufficiency of the lower limbs are well recognized; however, information on unusual causes are lacking. Yet, there are Doppler ultrasound pathognomonic signs that can help diagnosis some of the unusual cases. The aim of this paper is to itemize these Doppler ultrasound signs and to study their embryology and anatomical forms; three entities will be detailed. The first entity is intraosseous perforating vein (also called bone perforators) incompetence as related to abnormal intraosseous venous drainage. While their pathophysiology remains to be clarified, Doppler ultrasound makes their diagnosis easy and accurate. The second entity concerns sciatic nerve varicose veins, which may be truncular or plexiform at the femoral level, and they are explained by venous embryology. The presence of a tubular venous trunk, which is parallel to, but situated outside of the small saphenous vein, indicates that a varicose vein developed in the territory of the superficial fibular nerve and its fibular communicating branch. It is pathognomonic of sciatic nerve varicose veins. The third entity relates to when an inguinal leak point has a normal anatomical drainage path, but with a flow that is reversed secondary to intrapelvic venous hyperpressure, allowing pelvic varicose veins to drain to the lower limb. The presence of a dystrophic venous network, which is dilated, tortuous, and incontinent, located above the inguinal ligament is pathognomonic of the presence of this inguinal venous reflux of pelvic origin.

Introduction

Beside the classic causes of superficial varicose veins in the lower limbs (ie, insufficiency of the great or small saphenous veins or incompetence of standard perforating veins), some specific anatomic sources must be known. They are detected by Doppler ultrasound (DUS) pathognomonic criteria. The DUS diagnosis with these criteria does not require specific equipment. All current devices have sufficient ultrasound imaging quality and Doppler sensitivity. The anatomical structures studied in this article are all superficial. They should favor the high frequencies and wideband probes (eg, 8 to 15 Mhz) to obtain the best image resolution. Flow imaging is based on the Doppler effect, color mode, and wideband power mode. With the exception of the inguinal leak point, which is identified when a patient is lying down, all exams are done with the patient in a standing position. This paper will focus on three entities: incompetent intraosseous perforating veins, sciatic nerve varicose veins, and inguinal leak points.

Incompetent intraosseous perforating veins

For the first time, in 1962, Schobinger and Weinstein[1] described paratibial leg varicose veins in connection with intraosseous venous dilation. Around 20 years ago, the term "abnormal intraosseous venous drainage" appeared, but it was replaced recently with the term "bone perforator."[9] However, the term intraosseous perforating veins or transosseous veins seems more suitable for these veins that perforate the bone cortex and that are physiological and numerous. They allow bone venous drainage toward the great circulation. They can become pathological, dilated, incompetent, and feed leg varicose veins. The term

Figure 1. Typical clinical appearance of a varicose vein fed by a bone perforator: anterolateral side of the middle third of the leg.

"incompetent intraosseous perforator vein" or incompetent transosseous veins" is more accurate. The clinical expression of these varicose veins is stereotyped: these are paratibial varicose veins that have developed on the anteromedial side of the middle third of the leg *(Figure 1)*.

While a limited number of reports have been published,[1-10] this type of varicose vein does not seem so uncommon. In 2016, Ramelet et al[11] proposed a multicenter study on this specific type of varicose vein. Diaz-Candamio et al[3] describes intrafibular varicose veins, an incidental finding in context of pain, swelling, and deep vein thrombosis. Imaging findings are similar to those of intratibial varix. Ultrasound investigations revealed a reflux from the intraosseous veins, which feeds subcutaneous venous dilations via an orifice in the bone cortex *(Figure 2)*. The reflux is spontaneous or induced by the compression of muscles or varicose veins located below this cortical orifice. The cortical orifice is well visualized with DUS and it is always located at the anteromedial side of the middle third of the leg. It is characterized by a lack of continuity with the cortical bone. This bone defect is also clearly visible on a conventional radiography *(Figure 3)* and CT scan. It is sometimes possible to visualize intraosseous venous dilations under the cortical bone ultrasonically *(Figure 4)*.

Within certain limits, ultrasound can analyze formations inside bone structures. The ultrasound image is based on the detection of waves reflected by the different acoustic interfaces encountered by the incident wave. An acoustic interface is the boundary between two tissues of different acoustic impedance. Acoustic impedance is a physical quantity characterized by a number Z and expressed as kg×m^2/s. The greater the difference between two acoustic impedances, the higher the reflection coefficient (R) and the lower the transmission coefficient (T=1-R) per relation. Depending on the thickness and density of the bone, the transmission coefficient can exceed 60%. The transmitted waves, which are secondarily reflected, thus make it possible to analyze the structures behind the bone barrier. Conversely, the difference between the acoustic impedance of soft tissue and air is so great that less than 1% of the energy will be transmitted. The air is a true acoustic mirror and represents a much more impenetrable barrier to ultrasound than bone.

Although the clinical and ultrasonographic expressions of this specific type of varicose vein are well known, its pathophysiology remains to be clarified. The recall of bone vascularization enables a better understanding of

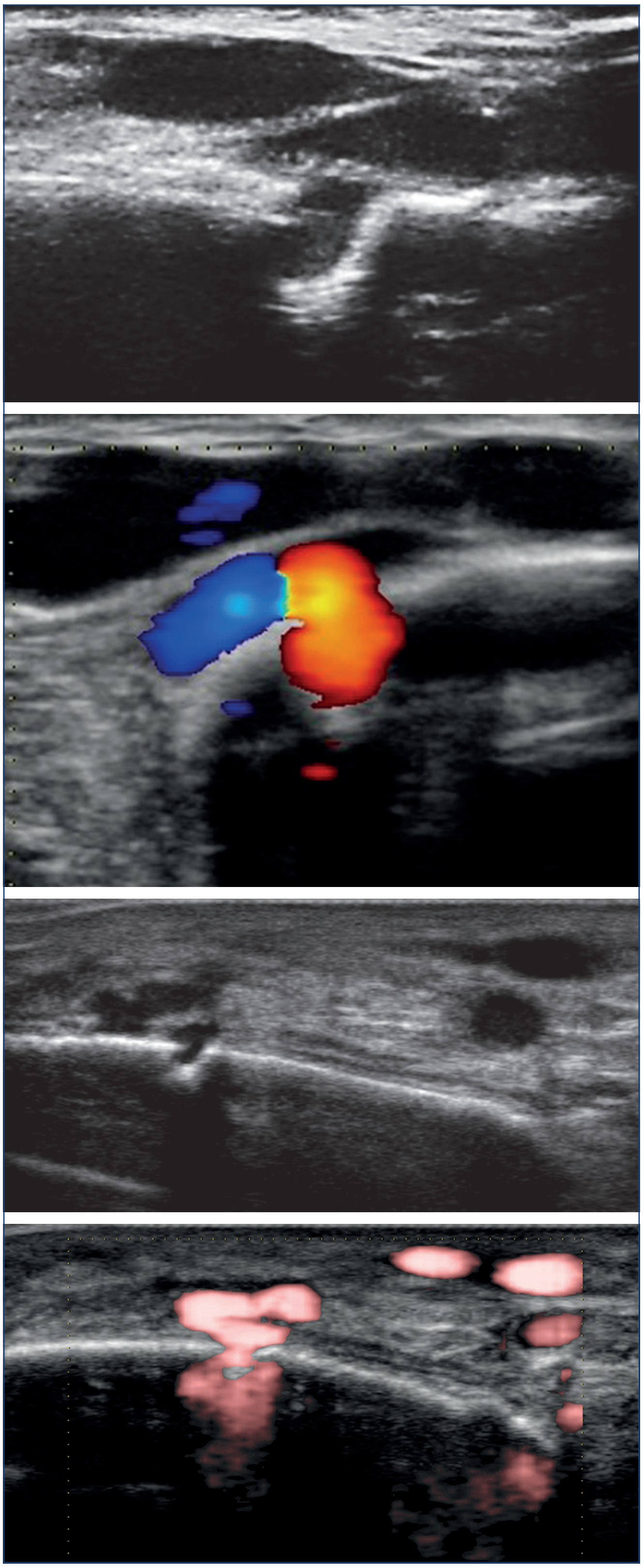


Figure 2. Ultrasonographic aspect of the incontinent bone perforator: reflux of the intraosseous circulation toward the great circulation, via a cortical defect.

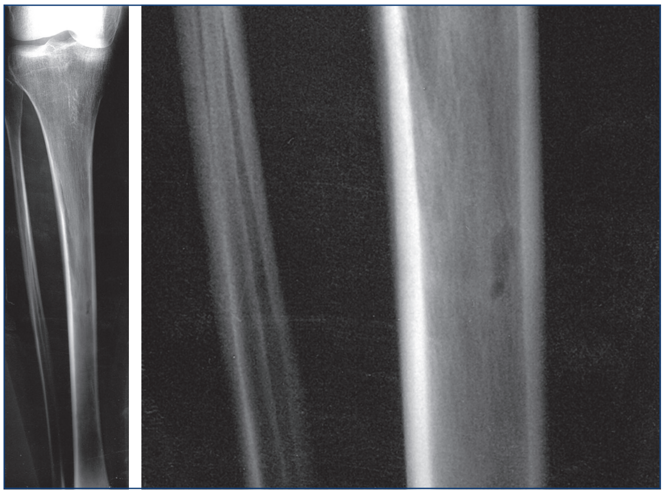


Figure 3. Radiological aspect of the cortical defect

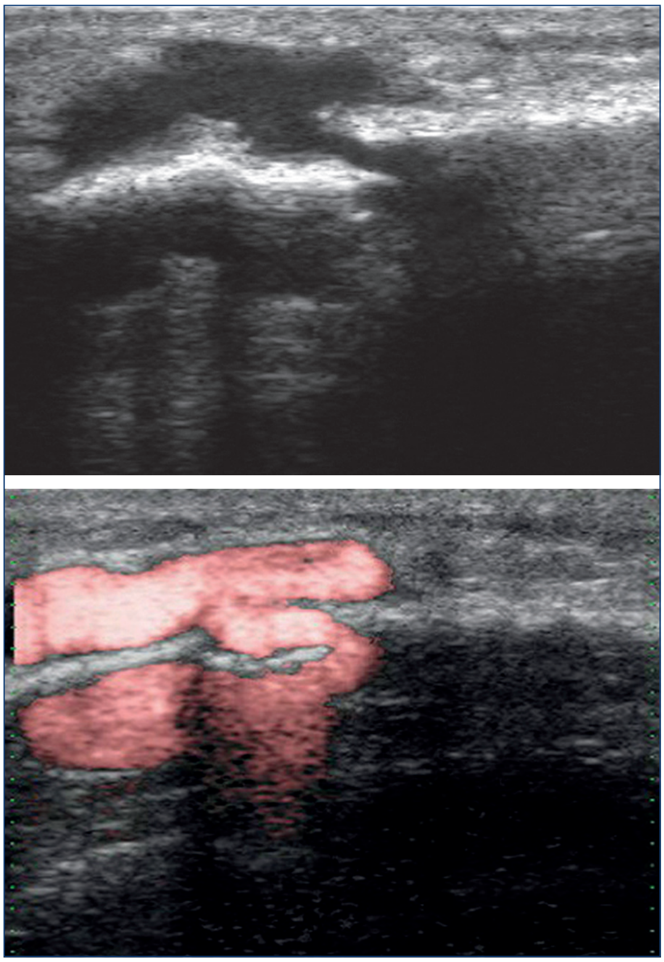


Figure 4. Visualization of subcortical venous dilations, which communicate via a cortical orifice, with extraosseous venous dilations.

this venous pathology. The arterial vascularization of the tibia is ensured by three networks *(Figure 5)*. First, the main food for the bone is provided by the intramedullary artery or feeder of the tibia branch of the posterior tibial artery. It enters the bone through the main feeder hole, located on the posterior side of the middle third of the tibia. In the bone marrow, it is divided into two branches, upper and lower, which will develop into an intramedullary mesh arterial network. Second, metaphyseal arteries vascularize the metaphysis and epiphysis. They enter the bone through specific secondary feeding holes and communicate with the intramedullary network. Third, periosteal arteries, located along the entire length of the tibia, are derived, depending on the segment considered, from the lower genicular arteries, posterior tibial arteries, anterior tibial arteries, and fibular arteries. They communicate with the intramedullary mesh network through multiple transcortical feeder orifices.

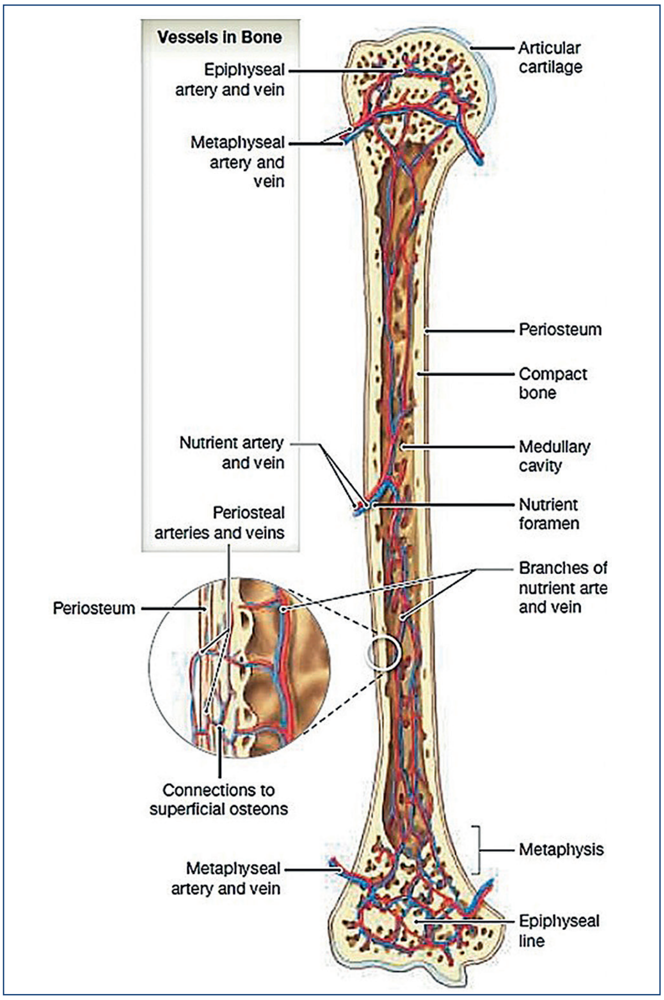


Figure 5. Schematic depiction of the arterial and venous vasculature of a long bone.

Venous vascularization is always described as parallel and satellite to arterial vascularization. These anatomical reminders allow two observations to be made: (i) multiple, transcortical, anatomical, and physiological communications exist between the intra- and extraosseous venous circulations; and (ii) the main venous draining pathway of the bone is the tibia feeder vein, which is externalized to the posterior aspect of the middle third of the tibia, to drain in turn into the posterior tibial vein. However, in all clinical cases, intraosseous reflux is externalized by a cortical orifice located at the anteromedial side of the middle third of the leg, in other words a secondary feeder orifice.

Several pathophysiological hypotheses can be proposed, including:

(i) Malformations during embryogenesis with either an absence of the posterior main feeder hole or hypo or agenesis of the tibia feeder vein;
(ii) Traumatic complications with either localized trauma with closure of the posterior main feeder or transverse diaphyseal fracture with interruption of venous continuity. However, in the multicenter study by Ramelet et al,[11] significant limb trauma was found in only 6 out of 34 cases (12%), but it should be noted that minor trauma was not reported in this study; and
(iii) Hyperpressure in the tibia feeder vein secondary to primary or postthrombotic reflux in the posterior tibial vein is possibly associated with proximal venous reflux. In this case, the posterior feeder orifice, which is physiologically the main drainage pathway for the intraosseous venous system, becomes a point of reflux, meaning that the intraosseous vein drainage is forced to use other secondary cortical orifices, which may progressively widen by erosion due to vascular hyperflow.

Some authors[2,4,8] describe, on CT scan and MRI, a dilatation of the tibia feeder vein in cases of an incontinent bone perforator, in favor of hyperpressure and/or venous stasis. However, Ramelet et al reported the presence of reflux of the posterior tibial vein in only 3 cases out of 35.[11]

In all of these hypotheses, an incontinent bone perforator is the expression of abnormal intraosseous venous drainage, but this raises three unresolved questions: (i) why is this pathology only located in the tibia and at the same level?; (ii) why is there a lack of a satellite artery?; and (iii) why does chemical ablation or phlebectomy of this vein have no detrimental effect,[11] if it ensures intraosseous venous drainage. Concerning the first question, only one case was described at the fibula, none at either the femur or the lateral or posterior side of the tibia. Hydrostatic pressure (making intraosseous venous drainage toward the great circulation more difficult) or mechanical stress do not explain this anatomical fixity. Regarding the second question, in the studies and in our experience, the presence of a satellite artery has not been recorded. If the pathological transosseous vein matches the dilation of a physiological communication between the centromedullary circulation and the periosteal circulation, it should be accompanied by an artery; however, this small caliber artery could be difficult to identify by DUS. Lastly, the last question leads to the proposal of a fourth pathogenic hypothesis–a pathological transosseous vein could be a persistent embryonic vein, and the other bone drainage pathways are normal. This fourth hypothesis would help answer the three previous questions.

Key points

- Transosseous vein or intraosseous perforating vein are better term than bone perforator.
- These veins are numerous and physiological.
- The main transosseous vein is the drainage pathway for the feeder vein from the tibia to the posterior tibial vein. The other drainage pathways mainly correspond to the connections between the feeder vein of the tibia and the periosteal veins.
- Transosseous veins can become pathological after intraosseous abnormal drainage of congenital or acquired origin.
- These veins could also be persistent embryonic veins, with no abnormal intraosseous venous drainage.
- In front of isolated varicose veins located on the anteromedial side of the leg, incompetent tibial perforators have to be searched for using DUS.
- The ultrasound diagnosis is simple. We propose three diagnostic ultrasound criteria: (i) venous dilatations on the medial side of the tibia above (and/or below) the cortical bone; (ii) a cortical defect; and (iii) flux through this cortical hole from intraosseous to extraosseous circulation.

Sciatic nerve varicosis

Varicose veins around the sciatic nerve have been known for a long time. The first description was that of Verneuil in 1890.[12] Since then, cases are episodically reported in the literature, with variable diagnostic circumstances: (i) in the context of Klippel Trenaunay syndrome[13]; (ii) during amputation of the thigh (discovery of a vascular pedicle, arterial and venous, around the sciatic nerve requiring a specific ligation)[14]; (iii) in front of recurrent sciatic pain in connection with the menstrual cycle[14]; or (iv) before recurrent varicose veins of the posterior side of the leg.[15]

In 2001, we proposed[16] an ultrasound definition of this varicose vein, based on its embryological origins and nerve anatomy. In 2005, Ricci et al[17,18] completed this description by recalling the ultrasound semiology of the sciatic nerve and its branches of the popliteal fossa. The best way to understand the pathophysiological aspects of this varicose vein is to summarize Gillot's work on venous embryogenesis.[19-22] In the embryo, the capillary networks precede the appearance of the nerves, but remain, at first, undifferentiated. It is only after the appearance of the nerves and at their contact that these embryonic venous plexuses, initially dispersed, will concentrate and differentiate. For the record, there are variations. Some veins have no nerve director (for example, at the level of the lower limb, the angio-directing element of the deep femoral and fibular veins is the femoral or fibular diaphysis, respectively). Three main angiogenic nerves intervene in the embryological development of the veins of the lower limbs. They are classified by their relation to the axis of the member: (i) the axial nervous plexus of the embryo will become, in an adult, the sciatic nerve in the thigh, the tibial nerve in the popliteal region, and the sural nerve in the leg; (ii) in front of this axis, the preaxial nervous plexus of the embryo will become the femoral nerve; and (iii) behind this axis, the postaxial nervous plexus will become the posterior femoral cutaneous nerve.

In contact with each nervous plexus, a satellite venous plexus grows *(Figure 6)*. During embryologic development, these venous, axial, and pre- and postaxial plexuses expand or regress, leading to the final venous anatomical arrangement after the formation of interplexus anastomoses. From the evolution of the axial and preaxial venous plexuses, Gillot proposed three possible arrangements for the venous drainage of the thigh, defining three types. Evolution type 1 *(Figure 7)* is the most common where the axial system regresses. There are only a few discontinuous venous arches along the sciatic nerve that communicate on several levels with the deep femoral vein. The preaxial system normally evolves toward the femoral vein, which then becomes the main venous return pathway in the thigh. Evolution type 2 *(Figure 8)* occurs when the preaxial

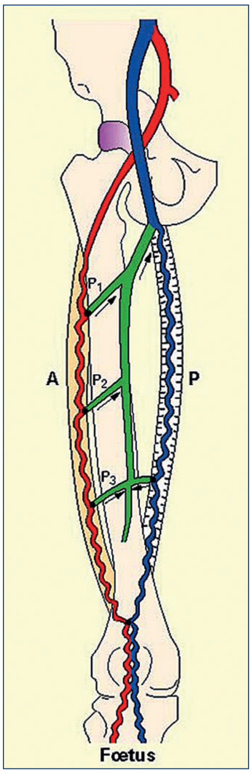


Figure 6.

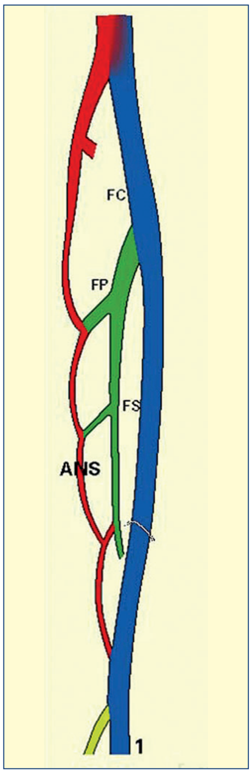


Figure 7.

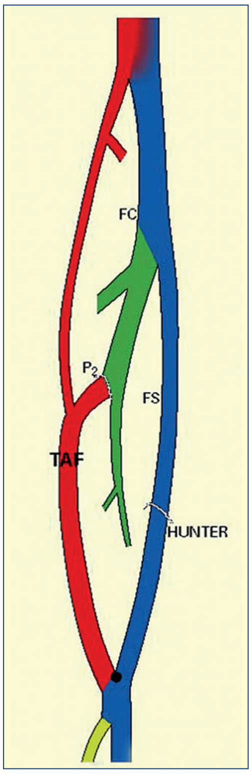


Figure 8.

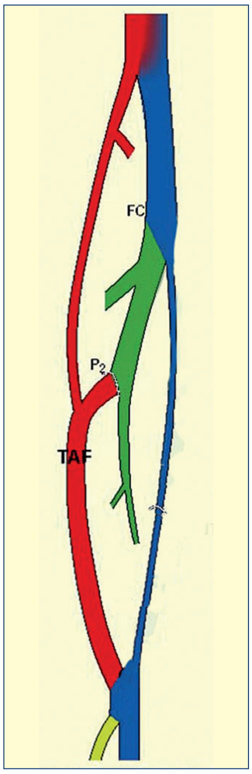


Figure 9.

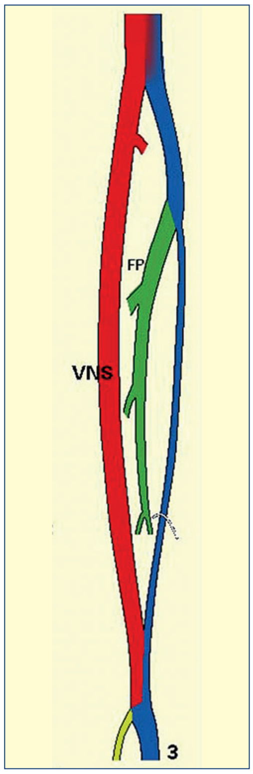


Figure 10.

Figure 6. Schematic depiction of embryonic venous plexuses.

Axial system (A); preaxial system (P); perforating veins (P_1, P_2, P_3). For simplicity, the postaxial system is not shown.

Image courtesy of C. Gillot.

Figure 7. Evolution type 1.

Evolution of the preaxial system to the femoral vein (FS). There is a regression of the postaxial system, which is reduced to simple discontinuous arches (ANS) that communicate with the deep femoral vein (FP). The femoral vein is the main route for venous drainage of the lower limb.

Image courtesy of C. Gillot.

Figure 8. Evolution type 2.

Normal evolution of the preaxial system to the femoral vein. Nonregression of the axial system, which results in a tubular vein, ie, the axiofemoral trunk (TAF). There is direct communication between the popliteal vein and most often the deep femoral vein, but sometimes the common femoral vein. Two equivalent lower limb venous drainage pathways.

Image courtesy of C. Gillot.

Figure 9. Evolution type 2 - other modality.

In this case, there is involution of the preaxial system with hypo or agenesis of the femoral vein. The axiofemoral trunk (TAF) and the deep femoral vein are the main axis for the venous drainage of the lower limb.

Image courtesy of C. Gillot.

Figure 10. Evolution type 3.

Regression of the preaxial system with hypo or agenesis of the femoral vein. Nonregression of the axial system which results in a tubular vein, avalvulated, which is prolonged by the inferior gluteal vein (persistent sciatic vein), which becomes the main axis for drainage of the lower limbs.

Image courtesy of C. Gillot.

system can evolve normally toward the femoral vein, but the axial system does not regress and generates a tubular vein, named by Gillot as the axiofemoral trunk. It carries out a full-channel communication, without variation in size between the popliteal vein and most often the deep femoral vein, but sometimes the common femoral vein. According to the development of the femoral vein, the venous drainage of the thigh will then be ensured by two equivalent axes or preferably by this axiofemoral trunk *(Figure 9)*. Evolution type 3 *(Figure 10)* is a rare evolution type where the preaxial system does not develop; instead, it regresses toward femoral vein atresia or hypoplasia. The axial system evolves toward a tubular, avalvular vein, the persistent sciatic vein, which is prolonged by the lower gluteal vein. It provides the main venous drainage pathway of the limb from the popliteal vein up to the internal iliac vein.

The ultrasound aspect follows directly from these embryological evolutions. In type 2, the popliteal vein is prolonged by two axes *(Figure 11)*: the femoral vein, a more or less developed axis, at the medial side of the thigh is superficial and joins the common femoral vein and another deeper, median, sciatic nerve satellite, which usually drains to the upper third of the thigh into the deep femoral vein. When there are two popliteal roots, the most frequent case, we obtain an anatomical "X" arrangement of the popliteal vein. In type 3, the ultrasound appearance is similar in the popliteal fossa, but the femoral vein is more often atretic *(Figure 12)* and the deep, medial trunk, a satellite of the sciatic nerve, does not curve inward to the upper third of the thigh, but extends to the medial part of the proximal part of the thigh to the gluteal fold in order to join the lower gluteal vein. Reflux of the axiofemoral trunk

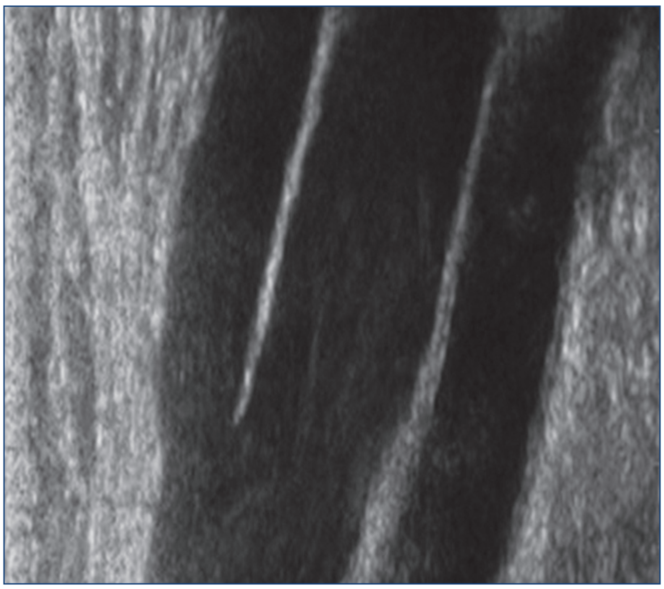


Figure 11. Ultrasound appearance of the extension of the popliteal vein by two equivalent axes: the femoral vein and the axiofemoral trunk.

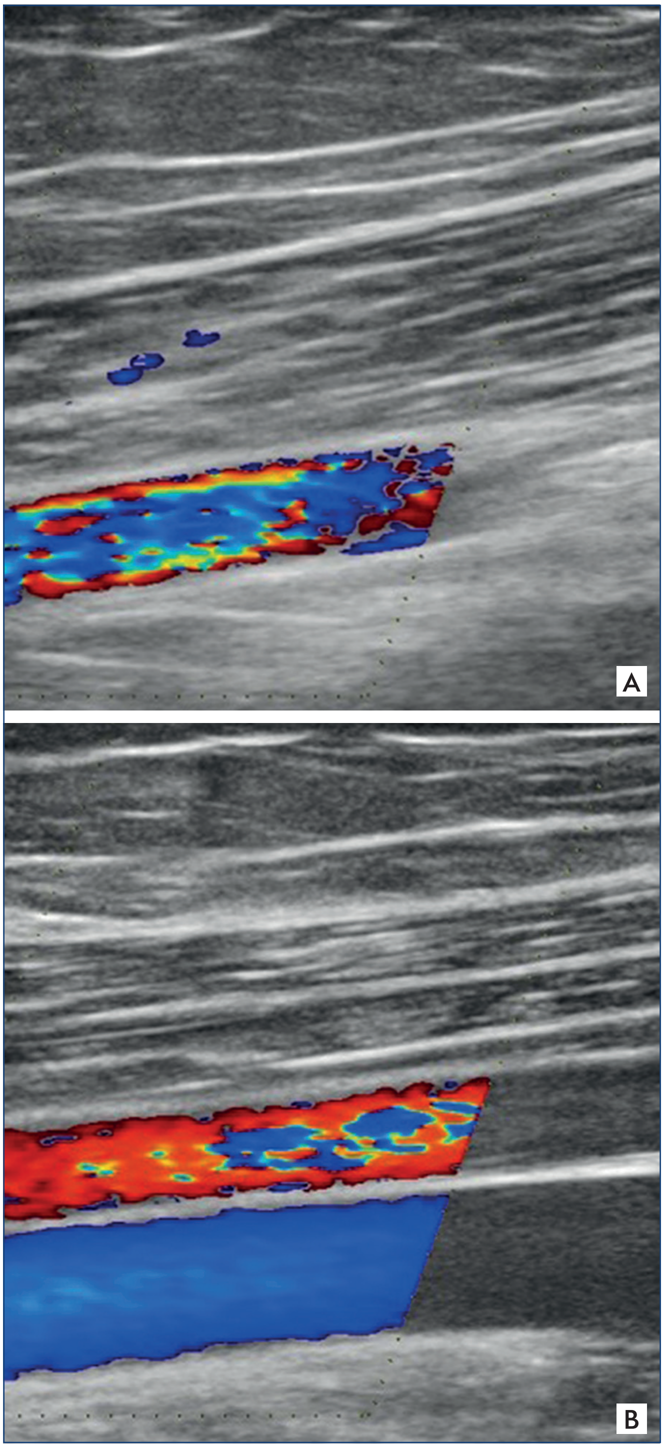


Figure 12. Femoral artery and vein.

Panel A. Femoral artery is present, but it is missing the femoral vein. Panel B. Femoral artery and veins are both present.

or the persistent sciatic vein is translated, on the femoral level, by a truncular varicose veins of the sciatic nerve *(Figure 13)*. Type 1 corresponds to modal venous embryogenesis. The embryonic axial venous system has regressed, persisting only in the form of discontinuous venous arches along the sciatic nerve. The venous drainage of this nerve originates from venules located in the nerve trunk. They communicate with a plexiform network located around the perinerve, which joins, according to different patterns,[23] the extraneuronal drainage veins.

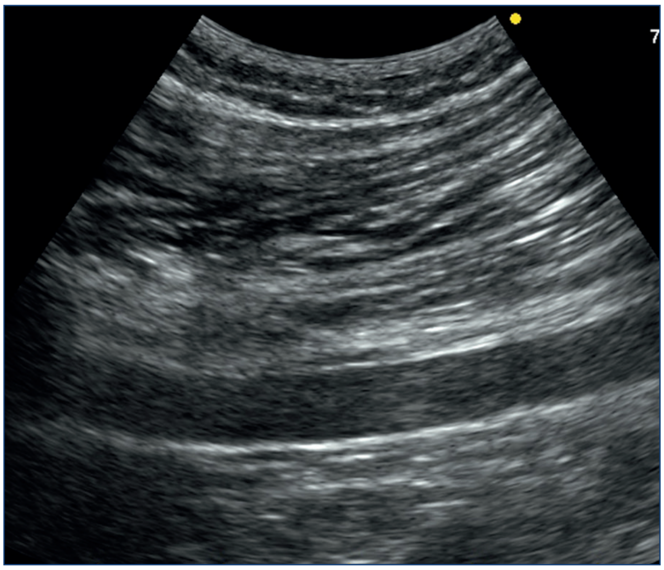


Figure 13. Truncular aspect of varicose veins of the sciatic nerve (tubular venous trunk, posterior, media, deep, in contact with the sciatic nerve).

It joins the deep femoral vein at the upper third of the thigh (ie, the axiofemoral trunk). It extends to the buttock and drains into the lower gluteal vein = persistent sciatic vein.

The nerves are well visualized on ultrasound.[17,24] In a longitudinal section, the nerves are visualized in the form of fibrillar structures, associating parallel striations, alternately hypo- and hyperechoic *(Figure 14)*. The hypoechoic striations correspond to the nerve fibers and the endonerve, and the hyperechoic streaks to the epinerve and perinerve. A "honeycomb" appearance is characteristic in cross sections. The main nerves involved in the expression of the sciatic nerve varicose veins are the tibial nerve, the common fibular nerve, the superficial fibular nerve, and its communicating branch. They are all very individualizable.

These veins have a small caliber; they are not spontaneously visible on ultrasound. They become so in case of reflux when they are dilated *(Figure 15)*, especially the perinervous veins

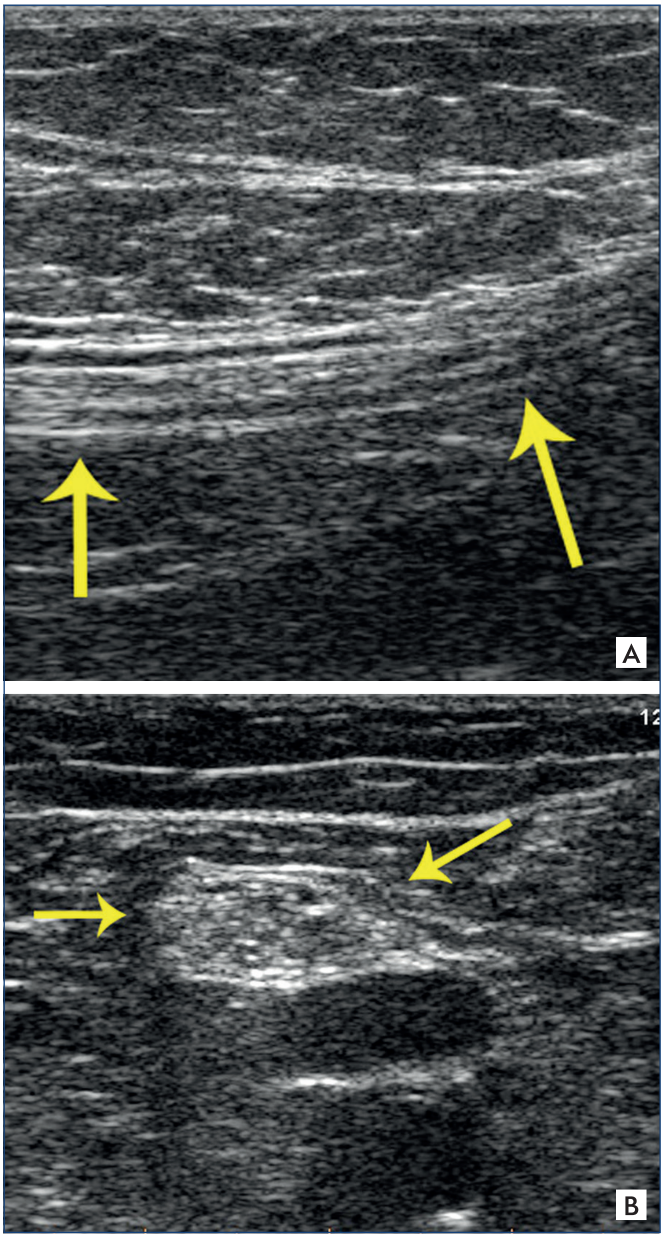


Figure 14. Sections of the sciatic nerve.

Panel A. Longitudinal section (fibrillary aspect). Panel B. Cross section (honeycomb appearance).

that dilate because the endovenous veins are contained by the nerve sheath. The expression of this varicose vein in the thigh is characterized by[16,24,25]: (i) the presence of a plexiform network that is located around the sciatic nerve *(Figure 16)* and is tortuous, more or less dilated, usually 3 to 5 mm, and refluxing; and (ii) veins located in the sheath of the nerve that are tubular, with a small caliber, and refluxing *(Figure 17)*.

The sciatic nerve divides, usually at the top of the popliteal rhombus, into its two terminal branches, ie, the tibial and

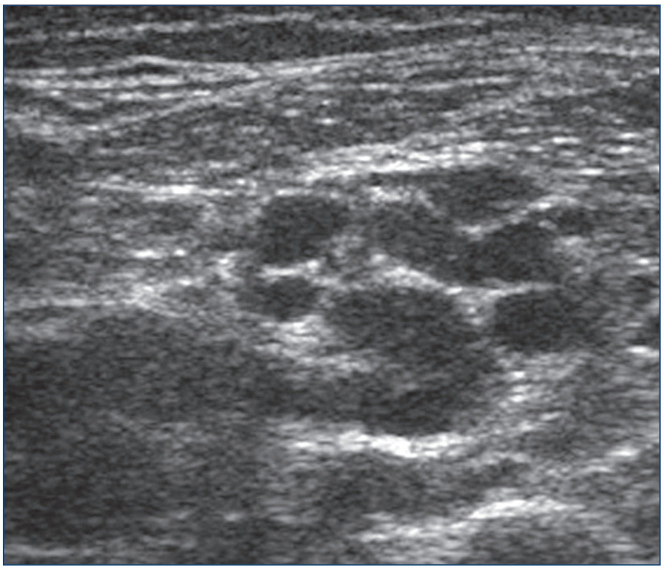


Figure 15. Cross section showing very dilated veins within the sheath of the sciatic nerve.

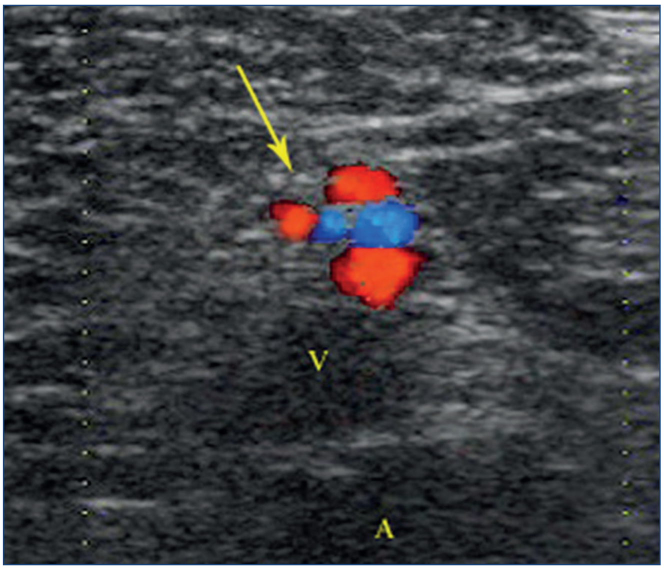


Figure 16. Cross section showing a venous, tortuous, and incontinent network running inside and around the sciatic nerve.

fibular nerves. Varicose veins may be of interest to these two nerves *(Figure 18)*, but it preferentially follows the common fibular nerve. The ultrasound aspect is the same as the thigh. In the thigh and in the popliteal fossa, this varicose vein is located under the muscular fascia. In the leg, an echographic criterion is pathognomonic[24,26]: the presence of a tubular trunk, parallel to the small saphenous vein, located outside (average distance≈25 mm) *(Figure 19)*, and incontinent, is, in our practice, always correlated with the presence of a varicose veins of the sciatic nerve. In fact, this vein, situated in a compartment analogous to

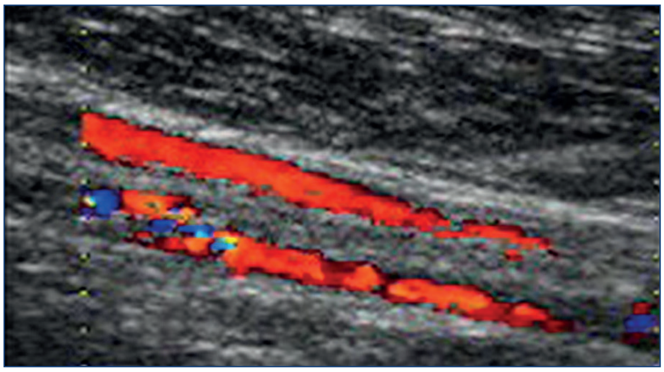


Figure 17. Longitudinal section showing small refluxing veins located within the nerve sheath.

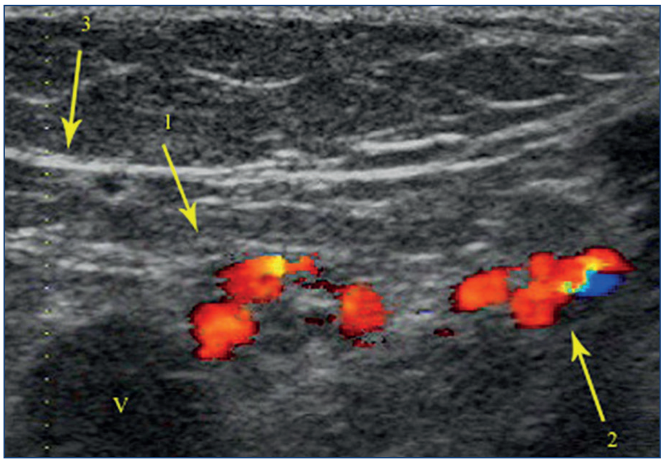


Figure 18. Cross section showing a venous, tortuous, and incontinent network within and around the tibial and fibular nerves.

Venous network within and around the tibial nerve (1). Venous network within and around the common fibular nerve (2). Popliteal vein (v).

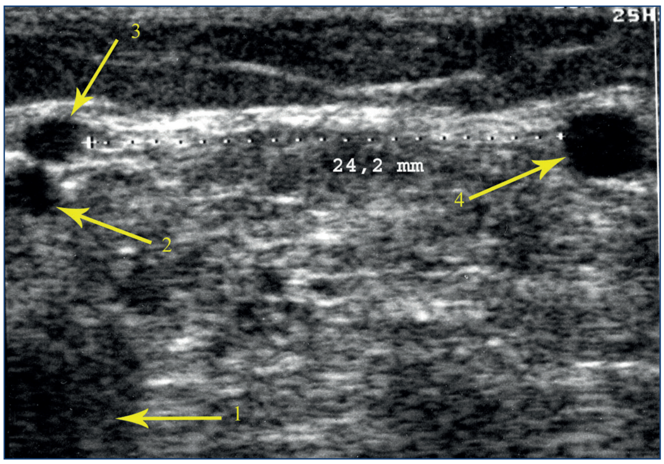


Figure 19. Cross section showing a tubular trunk that is parallel to and located outside of the small saphenous vein.

Popliteal vein (1). Vein of the cutaneous medial sural nerve (2). Small saphenous vein (3). Parallel vein in contact with the superficial fibular nerve or its communicating branch (4).

that of the small saphenous vein, follows the course of the superficial fibular nerve. It feeds a subcutaneous varicose vein of the posterior face of the middle third of the calf, which can communicate with the small saphenous vein, when the varicose follows the fibular communicating branch *(Figure 20)*.

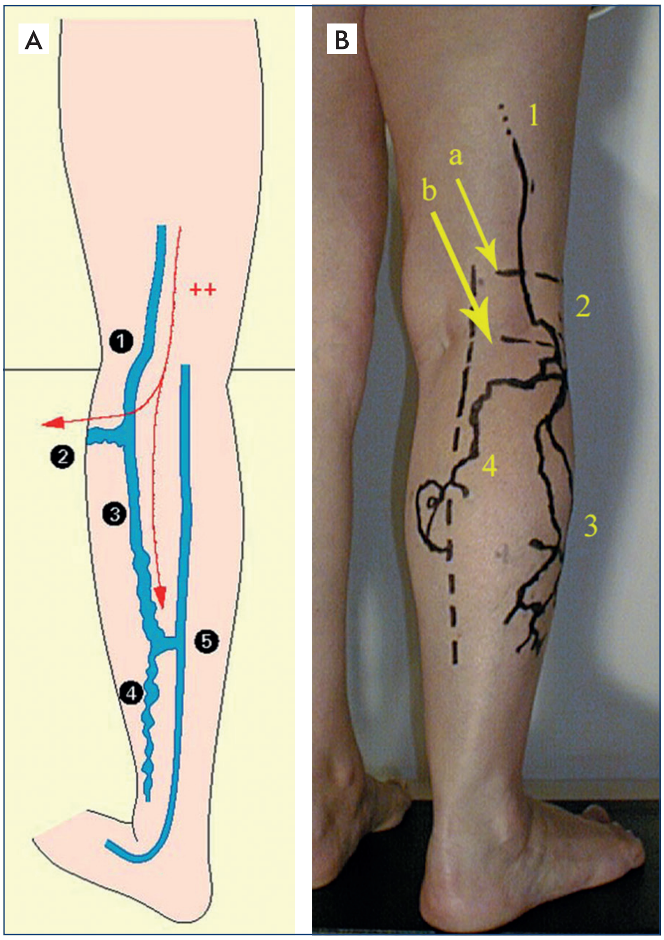


Figure 20. Calf varicose veins.

Panel A. Diagram of the appearance of calf varicose veins, fed by sciatic nerve varicose veins. Varicose veins along the common fibular nerve (1), which feeds a varicose vein that bypasses the fibula head by following the deep fibular nerve and an almost constant varicose vein that follows the superficial fibular nerve and its communicating branch (3): it corresponds to the pathognomonic ultrasound criterion. It usually joins the small saphenous vein at the lower third of the calf and feeds a posterolateral varicose veins of the lower half of the leg.

Panel B. Skin mapping of a varicose vein of the calf, fed by a sciatic nerve varicose vein. Varicose vein of the sciatic nerve (1), located under the muscle fascia (a). Varicose vein of the common fibular nerve, located between the muscle fascia and the saphenous fascia (2). Varicose vein of the superficial fibular nerve (3). Varicose vein of the communicating fibular branch (4). Varicose veins 3 and 4 are located above the saphenous fascia.

What is the pathophysiology of the varicose vein of the sciatic nerve?

A postthrombotic origin has been evoked. In practice, postthrombotic sequelae of devalvation are very rarely associated with sciatic nerve varicose veins. Moreover, it is difficult to conceive that the venous network of the sciatic nerve, which, apart from the truncular forms in the context of a persistent embryonic vein, is plexiform with a small caliber, can become an effective supply pathway for the lower limb in case of obstructive syndrome. In its plexiform form, it does not fit into a venous malformation context either. The most likely hypothesis is that a primitive reflux disease is localized to the veins of the sciatic nerve or that it is part of a more general disease. One of the afferents of the inferior gluteal vein drains the satellite veins of the sciatic nerve. Thus, reflux of the inferior gluteal vein may cause sciatic nerve varicose veins, which then becomes an indirect criterion for pelvic varicose veins.

Key points

- The positive diagnosis of the sciatic nerve varices is made by DUS.
- Its morphological expression is a direct result of embryogenesis: it can be plexiform or truncal. The persistent sciatic vein is only a rare form of this pathology.
- The presence of an incontinent, interfascial, tubular trunk, located outside of and parallel to the small saphenous vein is pathognomonic of sciatic nerve varicose veins.
- When the popliteal vein is extended by a tubular, median, deep vein (axiofemoral trunk or persistent sciatic vein), the presence of a functional femoral vein must be verified because this vein occasionally provides the main venous drainage of the limb from the popliteal vein up to the internal iliac vein.
- Varicose veins of the sciatic nerve may be an expression of incompetence of the lower gluteal vein.

Pathognomonic expression of a pelvic venous leak: the inguinal point or I point

Pelvic varices are very common in multiparous women, but, in the vast majority of cases, they are asymptomatic. When they are symptomatic, the clinical signs can be located: (i) on the pelvic level, in the form of pelvic congestion syndrome[27-29]; and/or (ii) on the lower limbs in the form of varicose veins originating from the pelvis.[24,30-34]

Transmission of pelvic reflux to the lower limbs requires communication between these two floors. In an anatomical drainage pathway, an inverted flow (from the pelvis to the lower limbs) defines a leak point. These leak points may or may not be systematized. In 1989, in an anatomical study, Lefebvre et al[30] had already described connections between extra and intra pelvic veins. In 2004, Franceschi and Bahnini described the DUS signs of 6 leak points originating from a hemipelvis (giving a total of 12 leak points).[31,32] Among these systematized leak points, there is the inguinal point. The superficial veins of the Mount of Venus and some epigastric veins preferentially drain into the uterine vein via the vein of the round ligament, which runs through the inguinal canal, unusual causes of varicose veins in the lower extremities.

The ultrasound expression of the inguinal point is unequivocal.[24,32,34] The reflux is externalized by the external orifice of the inguinal canal, situated above the inguinal ligament, outside the femoral vessels, by a trunk that travels from the abdominal-pelvic cavity toward the surface, with an internal concavity *(Figure 21)*. The reflux may be spontaneous with breathing or be caused by abdominal hyperpressure maneuvers (manual anterior compression of the abdomen or Valsalva maneuver). The examination can be positive in the decubitus position, and it is often sensitized in orthostatism.

The saphenofemoral junction is an intervalvular segment,[38] delimited by the preterminal valve and the terminal valve. This segment receives four major afferents[39]: the anterior saphenous vein, two abdominal afferents (the superficial epigastric vein and the superficial iliac circumflex vein), and a genital afferent (the lateral pudendal vein). Pieri et al[39] demonstrated that a truncular reflux of the terminal part of the great saphenous vein could be present, despite the continence of the terminal valve, if the preterminal valve is incontinent. In this case, the truncular reflux is most often fed by the abdominal or genital afferents. It may or may not be caused by the Valsalva maneuver. The Valsalva maneuver generates hyperpressure in the abdominal-pelvic cavity. If this hyperpressure causes truncular saphenous reflux, it involves the presence of incontinent communication between the abdominal-pelvic cavity and the lower limb. In other words, in front of a preterminal reflux caused by a Valsalva maneuver, it is necessary to search for a leak point of pelvic origin, usually an inguinal point or a perineal point.

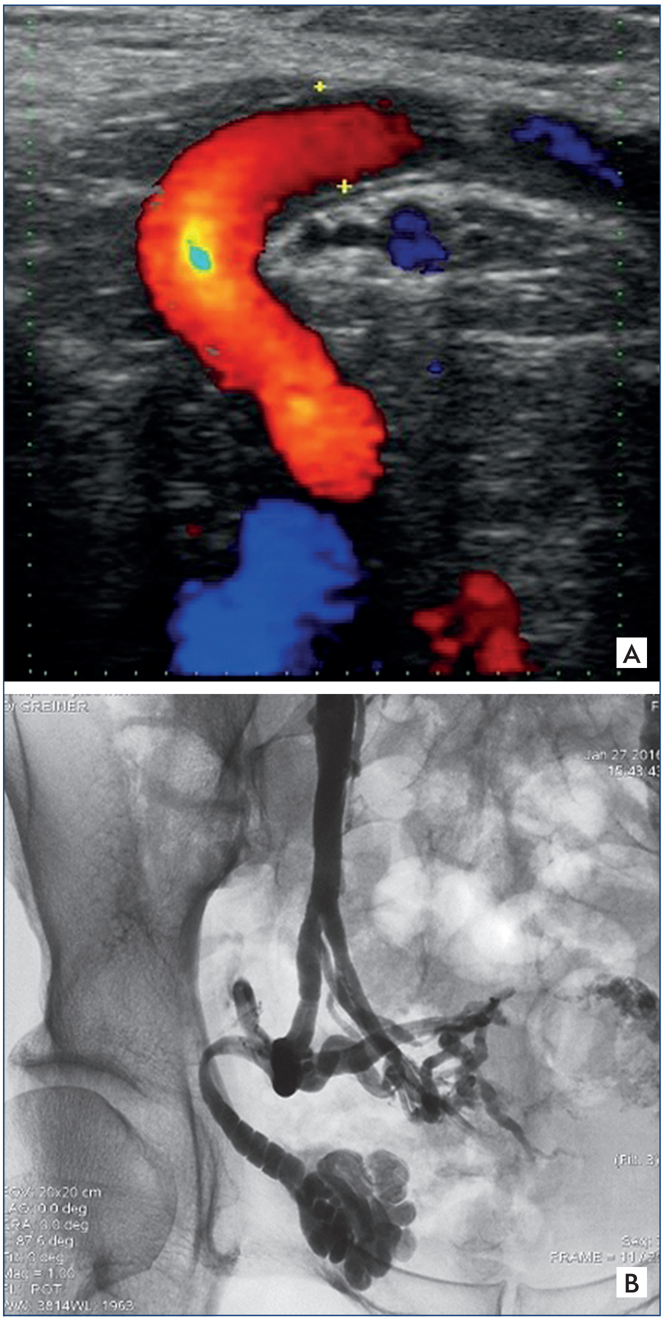


Figure 21. Iguinal point.

Panel A. Univocal ultrasound aspect of the inguinal point (I point). Incontinent tubular trunk that is externalized through the orifice of the inguinal canal, with a concave path inward.

Panel B. Phlebographic aspect of the I point (identical characteristics). Image courtesy of M. Greiner.

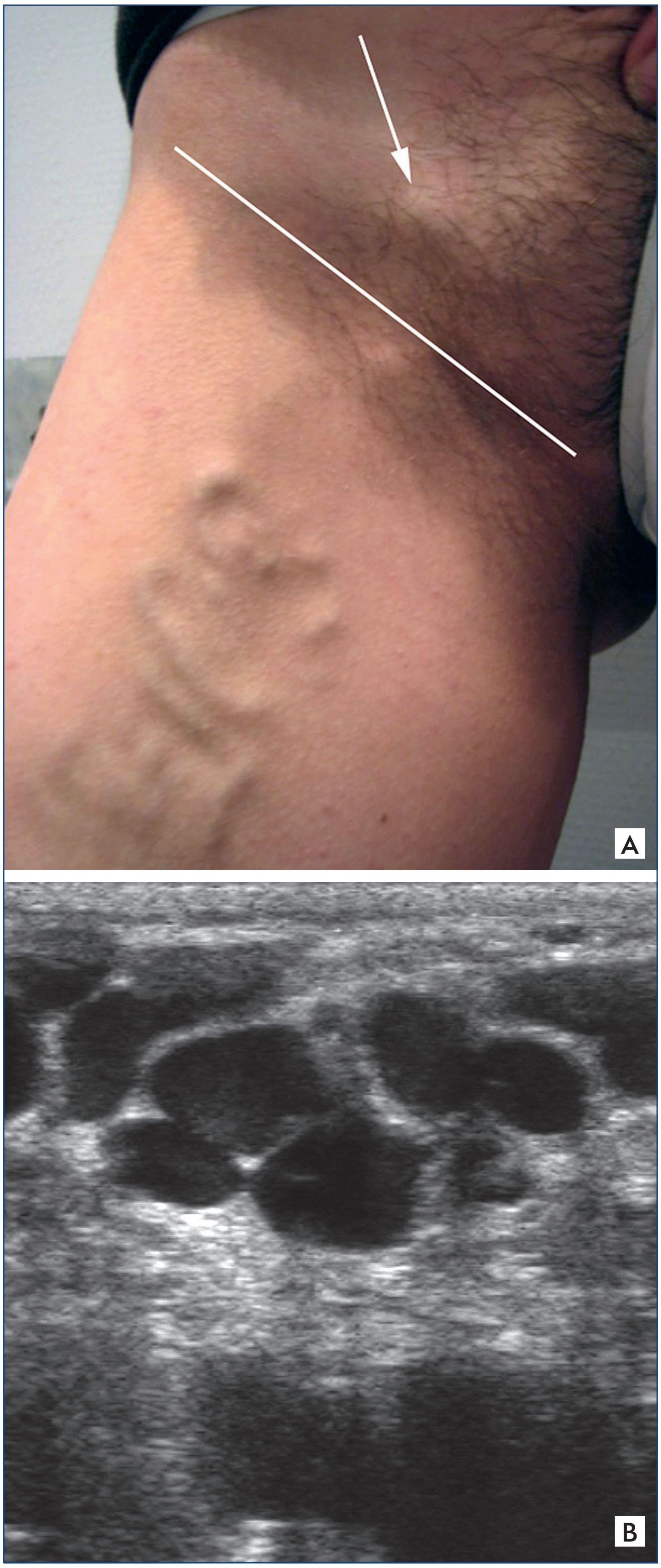


Figure 22. Dystrophic venous network.

Panel A. Clinical aspect of the dystrophic venous network (arrow) located above the inguinal canal.

Panel B. Ultrasound aspect of this dystrophic venous network (pathognomonic criterion of an inguinal point).

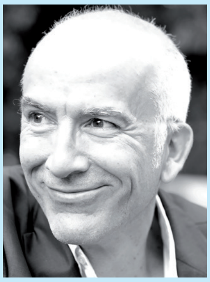
In our practice,[36,37] the presence of a dystrophic venous network, ie, dilated, tortuous, and incontinent, located above the inguinal ligament on either side of the saphenofemoral junction is pathognomonic of the presence of a I point *(Figure 22).*

Key points

- The inguinal point is an anatomical drainage pathway with inverted flow.
- It is always a drainage pathway for parametrial or uterine varicose veins.
- Its ultrasound appearance is unambiguous, with a pathway that has internal concavity.
- The presence of a dystrophic venous network located just above the inguinal ligament is pathognomonic of the presence of an inguinal leak point.

Conclusions

These few examples illustrate the contribution of ultrasound investigations to the assessment of superficial venous disease. Embryogenesis makes it possible to understand the anatomy and its variations. The expression of venous disease is polymorphic. However, some anatomical and hemodynamic patterns are easily identifiable through stereotyped or even pathognomonic ultrasound semiology. The aim is to achieve the most complete anatomical and hemodynamic mapping of superficial venous disease of the lower limbs.



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REFERENCES

1. Schobinger R, Weinstein CE. Varix involving the tibia. *J Bone Joint Surg Am.* 1962;44-A:371-376.
2. Boutin RD, Sartoris DJ, Rose SC, et al. Intraosseous venous drainage anomaly in patients with pretibial varices: imaging findings. *Radiology.* 1997;202:751-757.
3. Diaz-Candamio MJ, Lee VS, Golimbu CN, Scholes JV, Rofsky NM. Intrafibular varix: MR diagnosis. *J Comput Assist Tomogr.* 1999;23:328-330.
4. Peh WC, Wong JW, Tso WK, Chien EP. Intraosseous venous drainage anomaly of the tibia treated with imaging-guided sclerotherapy. *Br J Radiol.* 2000;73:80-82.
5. Jung SC, Lee W, Chung JW, et al. Unusual causes of varicose veins in the lower extremities: CT venographic and Doppler US finding. *Radiographics.* 2009;29:525-536.
6. Mirault T, Lambert M, Vinckier L, Lamotte C, Cousyn M, Hatron PY. Anomalous intraosseous venous drainage: a rare cause of pretibial varicose veins [article in French]. *J Mal Vasc.* 2010;35:373-376.
7. Lemasle P. Cas clinique in atlas d'écho-anatomie – bases biophysiques de l'imagerie sonore. Boulogne sur Seine : LaboratoiresTonipharm. 2011.
8. Kwee RM, Kavanagh EC, Adriaensen ME. Intraosseous venous drainage of pretibial varices. *Skeletal Radiol.* 2013;42:843-847.
9. Ramelet AA. Maladie veineuse chronique sur anomalie de drainage veineux intraosseux: perforantes osseuses? *Phébologie.* 2014;67:78-80.
10. Moraes FB, Camelo CP, Brandão ML, Fávaro PI, Barbosa TA, Barbosa RC. Intraosseous anomalous drainage: a rare case of pretibial varicos vein. *Rev Bras Ortop.* 2016;51(6):716-719.
11. Ramelet AA, Crebassa V, D'Alotto C, et al. Anomalous intraosseous venous drainage: bone perforators? *Phlebology.* 2016;32(4):241-248.
12. Verneuil A. Traité de chirurgie de Duplay et Reclus. 1890 ; tome 2 :221.
13. Servelle M. Pathologie vasculaire. Les affections veineuses. Masson, Paris. 1978;44-75.
14. Thiery L. La veine du nerf sciatique. Impact et thérapeutique. *Phlébologie.* 1988;41:687-689.
15. Trigaux JP, Vanbeers BE, Delchambre FE, de Fays FM, Schoevaerdts JC. Sciatic venous drainage demonstrated par varicography in patients with a patent deep venous system. *Cardiovasc Intervent Radio.* 1989;12:103-106.
16. Lemasle P, Uhl JF, Lefebvre-Vilardebo M, et al. Veine du nerf sciatique et maladie variqueuse : aspects écho-anatomiques et hémodynamiques. *Phlébologie.* 2001;54:219-228.
17. Ricci S. Observation ultrasonique du nerf sciatique et de ses branches à la fosse poplitée : toujours visible, jamais observé. *Phlébologie.* 2005;58(2):197-202.
18. Ricci S, Georgiev M, Jawien A, et al. Sciatic nerve varices. *Eur J Vasc Endo Vasc Surg.* 2005;29:83-87.
19. Gillot C. Le prolongement post-axial de la petite veine saphène. Etude anatomique – Considérations fonctionnelles – Intérêt pathologique. *Phlébologie.* 2000;53:295-325.
20. Gillot C. Dispositifs veineux poplités : hypothèses et certitudes. *Phlébologie.* 1998;51:65-74.
21. Gillot C. Atlas anatomique des dispositifs veineux superficiels des membres inférieurs. Editions phlébologiques françaises : Paris, 1998.
22. Gillot C. Variations et valvulation du système tronculaire fémoro-poplité. *Phlébologie.* 1991;44:537-76.
23. Del Pinãl F, Taylor GI. The venous drainage of nerves; anatomical study, and clinical implications. *Br J Plast Surg.* 1990;43:511-520.
24. Lemasle P. Atlas d'écho-anatomie veineuse superficielle. La varicose pelvienne de la femme (tome 5), 2006 Laboratoires IPSEN - 2008 Laboratoires TONIPHARM, Paris.
25. Labropoulos N, Tassiopoulos AK, Gasparis AP, Pappas PJ. Veins along the course of the sciatic nerve. *J Vasc Surg.* 2009;49(3):690-696.
26. Lemasle P. De la clinique aux ultrasons : veine du nerf sciatique. *Phlébologie.* 2003;56:219-228.
27. Hobbs JT. The pelvic congestion syndrome. *Br J Hosp Med.* 1990;43:200-206.
28. Villavicencio JL, Gillespie D, Durholt S, et al. Diagnosis and treatment of the pelvic venous disorders: pelvic congestion and pelvic dumping syndromes. In: Cann CC, ed. *Surgical Management of Venous Disease.* 1st ed. Baltimore, MD, USA: Williams and Wilkins; 1997;462-483.
29. Greiner M. Syndrome de congestion pelvienne : diagnostic et traitement. *Phlébologie.* 2005;58:293-298.
30. Lefebvre D, Bastide G, Vaysse Ph, et al. Connexions veineuses intra et extra-pelviennes. Etude anatomique. *Phlébologie.* 1989;42(3):385-389.
31. Franceschi C, Bahnini A. Points de fuite pelviens viscéraux et varices des membres inférieurs. *Phlébologie.* 2004;57:237-242.
32. Franceschi C, Bahnini A. Treatment of lower extremity venous insufficiency due to pelvic leak points in women. *Ann Vasc Surg.* 2005;19:284-288.
33. Perrin MR, Labropoulos N, Leon LR Jr. Presentation of the patient with recurrent varices after surgery (REVAS). *J Vasc Surg.* 2006;2:327-323.
34. Lemasle P. Stratégie diagnostique dans la prise en charge de la varicose pelvienne de la femme. *Phlébologie.* 2009;62(3):21-39.
35. García-Gimeno M, Rodríguez-Camarero S, Tagarro-Villalba S, et al. Duplex mapping of 2036 primary varicose veins. Duplex mapping of 2036 primary varicose veins. *J Vasc Surg.* 2009;49(3):681-689.
36. Lemasle P, Greiner M. Place de l'exploration ultrasonore dans le bilan de l'insuffisance veineuse pelvienne de la femme in Ultrasons et phlébologie. Société Française de phlébologie. Editions phlébologiques française. Paris 2017;2:24.
37. Lemasle P, Greiner M. Duplex ultrsound investigation in pelvic congestion syndrome. technique and results. *Phlebolymphology.* 2017;24(2):79-87.
38. Pieri A, Vannuzzi A, Duranti A, et al. Rôle central de la valvule pré-ostiale de la saphène interne dans la genèse des varices tronculaires des membres inférieurs. *Phlébologie.* 1995;48(2):227-238.
39. Mühlberger D, Morandini L, Brenner E. Venous valves and major superficial tributary veins near the saphenofémoral junction. *J Vasc Surg.* 2009;49:1562-1569.

Which venous patients need to be investigated with air plethysmography and why?

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Abstract

Air plethysmography (APG) is a small, lightweight device that measures change in calf volume in response to various maneuvers. Of these, elevation and dependency are the most important because they are gravitational maneuvers and, without gravity, venous insufficiency would be rare. The hypothesis underpinning the value of APG is that rapid calf expansion on dependency or a slow reduction in calf volume on leg elevation are a failure of our natural defense mechanisms against gravity. The APG parameters quantifying this are termed the venous filing index (VFI) and the venous drainage index (VDI), respectively. They are measured in mL/s for consistency and comparability and they serve to quantify the observations of Trendelenburg. The VFI and VDI may have relationships to ultrasound phenomena or imaging in individual veins, like reflux or iliac occlusion. However, APG assesses the calf as a global unit, providing the rate of volume change. In this way, it behaves as a pure test, uncorrupted by words like reflux, resistance, pressure, and wall tension, which are difficult to measure and are only part of any venous pathology. If the pathology is considered a chronic insufficiency of venous drainage of the leg, then APG is the noninvasive, objective test to quantify this whenever insufficiency is suspected.

In memory of Dr Evi Kalodiki (1956–2018) who dedicated her working life to APG research.

Introduction

Air plethysmography (APG®, ACI Medical LLC, San Marcos, CA, USA) testing has undergone many modifications in the last few years, including modernization and digitalization of the apparatus, introduction of new parameters, and changes in the interpretation of old parameters. In contrast to duplex ultrasound, the whole apparatus can fit into a paper takeaway lunch bag without requiring wheels for portability *(Figure 1)*. Tracings are stored as file icons, which, when opened, can be displayed on a touch screen. Three taps with a pointer are all that is required for an onscreen display of the venous filling index (VFI) and the venous drainage index (VDI). Furthermore, the output is a volume versus time chart, which

Figure 1. Air plethysmography apparatus.

The entire apparatus, excluding laptop, weighs 1.8 kg and fits into a paper takeaway lunch bag.

requires minimal training for interpretation. The ease and convenience of these new modifications has placed the test in an outpatient setting, which can be performed by allied health care professionals. The test and apparatus *(Figure 2)* can be compared (in time and simplicity) with measuring the ankle brachial pressure index (ABPI).

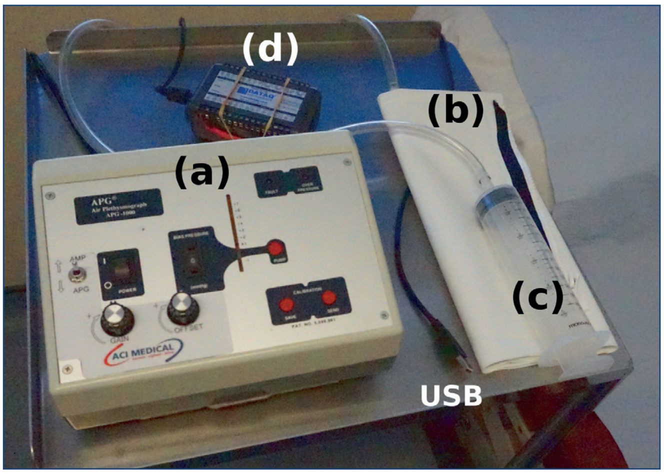

Figure 2. Components of an air plethysmography apparatus.

The APG apparatus comprises a pump (a), sensor calf cuff (b), calibration syringe (c), and data unit (d), which connects to a laptop via a USB cable. It has only 8 buttons, including the on-off switch.

Failings of clinical assessment

Varicose veins with reflux are a common finding in the general population[1] and reflux may occur in legs without evidence of venous disease.[2] Symptoms of leg pain, discomfort, heaviness, swelling, cramps, and pruritus are also common,[3] and, after prolonged standing, most will develop some of these symptoms as well as edema,[4] which may not be venous in origin. A relationship between lesion assessment and leg symptoms is easy to propose. However, the clinical dilemma is to determine whether there is a true relationship between the symptoms and signs of the patient or whether the reality is only a statistical association. Venous-like symptoms are also common in other diseases, which confounds clinical assessment.[5] Leg symptoms are often unexplained[6] and varicose vein symptoms may occur more often in people without varicose veins.[7] Furthermore, there is lack of a strong relationship between symptoms and signs. Approximately 20% of patients with venous leg ulcerations have no visible varicose veins[8] and an equal percentage are painless.[9] Phlebologists will all have come across patients who have venous ulcers with minimal symptoms or quality of life (QOL) impairment. It is also common to see patients with extensive skin changes who present only because their partner has concerns regarding the appearance. The neuropathy of venous disease may play a role in this discord,[10] which raises the hypothesis that, like the neuropathic disability of the diabetic foot, venous-like symptoms are a healthy phenomenon designed to offset venous disease progression by invoking remedial action through elevation and compression hosiery.

Unfortunately, current clinical assessments using research questionnaires, such as the Aberdeen varicose vein questionnaire (AVVQ)[11] and the venous clinical severity score (VCSS),[12] are not separated into the classic symptoms and signs. Though the AVVQ QOL questionnaire is promoted as a patient-reported outcome measure (PROM), the reality is that the score for each question has already been decided by the clinician to 3 decimal places, regardless of the value/relevance of that question to the individual patient.[13] Perhaps PROM should be replaced with a clinician-scored outcome measure (CSOM). Furthermore, QOL assessment includes the contralateral leg as part of the final score. Disadvantages of the VCSS include the negative impact of treatment scoring with a compression stocking, lack of responsiveness, and statistical noise regarding ulceration in study populations who are classified as C_2 to C_5 according to the clinical, etiological, anatomical, and pathophysiological (CEAP) classification[14] who do not have ulcers.[15] The Villalta scale in the diagnosis and assessment of postthrombotic syndrome also has problems.[16] While it separates symptoms and signs conveniently, albeit unevenly with 5 symptoms versus 6 signs, it has been shown to be nonspecific. With this scale, many patients with nonthrombotic venous disease have a score above the threshold defining postthrombotic syndrome even though they have never had a thrombosis event[17] or deep venous reflux. Surprisingly, specific common symptoms, such as venous claudication[18] and diagnostic signs, such as abdominal collaterals[19] are not included in the Villalta scale.

The prime function of veins is drainage. Therefore, the strategy of recommending APG for all patients is that it provides an objective test to quantify the degree of functional impairment (insufficiency) for screening, diagnosis, treatment, and follow-up. In this way, it acts as a bridge rationalizing the relationship between symptoms and signs. Furthermore, it serves to complete the Venn diagram of treatment aims to specify the domains that need improving *(Figure 3)*, which may be a step closer toward personalized outcomes.

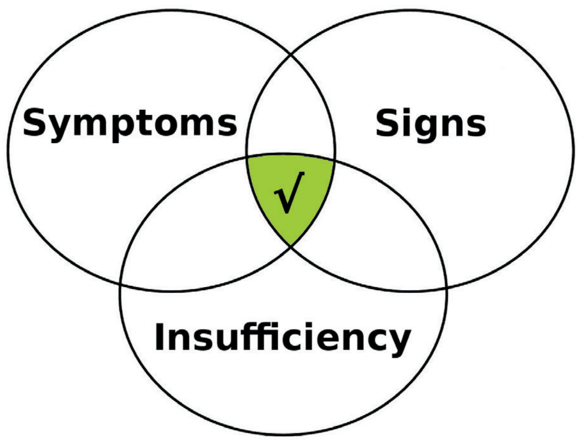

Figure 3. The Venn diagram of treatment aims that define the domains requiring improvement.

The relative importance of incomes, such as symptoms, signs, and functional insufficiency, should be established before their relative importance in outcomes can be determined.

Most diseases rely on an objective assessment in addition to clinical symptoms and signs. Unfortunately, ultrasound parameters do not fill this need because they are unable to quantify venous insufficiency reliably[20,21] and assessments are limited to individual veins and the experience and capability of the investigator. The high prevalence of venous reflux in the general population[2] demands some form of quantification in order to assess its hemodynamic relevance. Similarly, venous obstruction is difficult to measure and not possible to quantify by ultrasound. Pelvic veins are hard to visualize and their position changes with different postures.[22] Venous tone and muscle pump function, both very relevant to venous drainage, cannot be measured with ultrasound. These limitations pave the way for APG as a device with the potential to quantify all the main components of venous insufficiency.

Redefining existing parameters

The outflow fraction of venous occlusion plethysmography has been traditionally used as a way of assessing venous obstruction; it is the reduction in calf volume caused by venous discharge from a congested calf upon sudden deflation of an 80 mm Hg pneumatic thigh cuff in 1 second *(Figure 4)*.[23] This procedure is performed in the supine position and expressed as a percentage. Although the outflow fraction had promise in assessing outflow obstruction, it is not supported by evidence.[24-26] Early data suggested that the outflow fraction may be an index of venous tone,[27,28] and recent data have demonstrated that, if the tone of the calf is increased with a graduated elastic compression stocking, the outflow fraction increases from a median of 44% to 63%.[29] Use of the outflow fraction as an obstruction parameter is not logical. On thigh cuff deflation, the discharged calf blood will fill the empty thigh veins caused by the cuff, which is irrespective of whether there is any pelvic venous obstruction. If the outflow fraction is impaired in patients following a deep vein thrombosis (DVT), the cause is usually an increase in vein stiffness with a reduction in the vein wall tone as a result of inflammatory scarring *(Figure 5)*.

The ejection fraction parameter is valid, but it must be remembered that it is a relative parameter and that the classic test used to induce muscle pump ejection has changed. The ejection fraction is the reduction in the volume of the calf as a percentage of the working venous volume from a single tiptoe ankle flexion maneuver *(Figure 4)*. Increases in calf venous volume and calf perforating vein incompetence are likely to reduce the ejection fraction because the same volume of ejected blood from the pumping chamber will go out of the calf or be discharged into superficial calf veins in the face of an increased working venous volume.[30] Thus, the ejection fraction (EF) ratio decreases.

It is of interest that the tiptoe maneuver is suboptimal as a pumping test. It should be replaced with a body weight transfer maneuver from one leg to the other. Recent work has demonstrated that yhere was asignificant increase in the median (inter–quartile range) EF using this maneueves in healthy subjects versus the gold standard tiptoe maneuver (60[54-64] vs 43[31-53], P<0.0005).[30] Furthermore, the body weight transfer maneuver does not require ankle joint movement *(Figure 6)*. The volume shifts in a weight transfer have been appreciated by colleagues that practice saphenous sparing surgery using the Paranà test (isometric contractions response of the leg whilst standing caused by a gentle unexpected puh or pull by the investigator) as a way of inducing reflux.[31] An explanation of the success of this test could be that the isometric calf muscle contraction of the surrounding soleal venous sinuses involved in balance is more significant than the spring–like contractions of the gastrocnemius muscle involved in tiptoe activities, such as running.

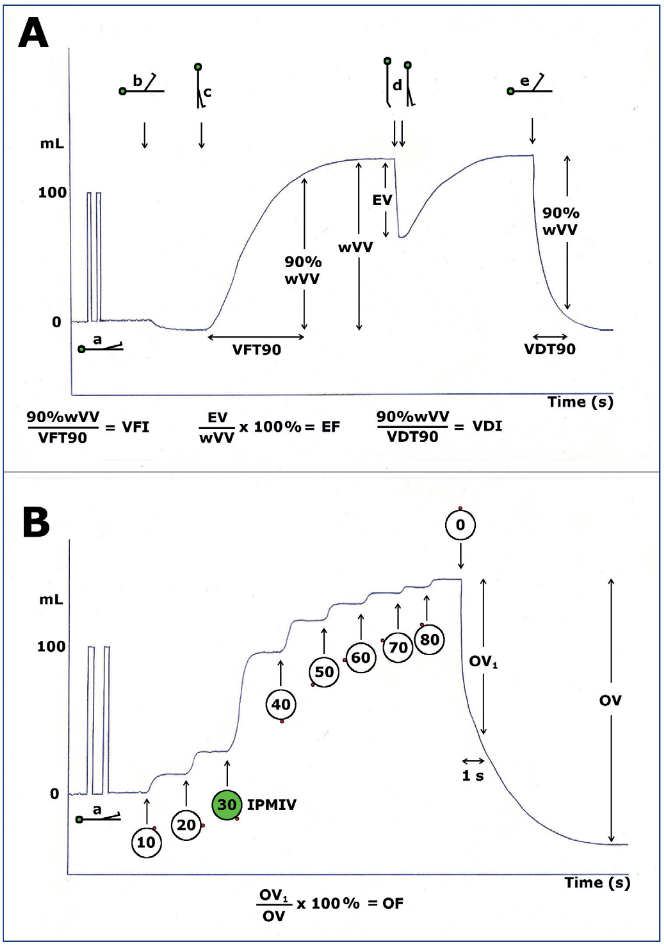

Figure 4. Schematic representation of the plethysmography parameters.

Panel A. Standard plethysmography. Maneuvers (arrowed events) that provoke changes in calf volume: calibration position (a), 70 degrees drainage position (b), standing and nonweight bearing (c), tiptoe on both legs up and down (d), and back to the drainage position (e).

Panel B. Venous occlusion plethysmography. The thigh cuff is inflated in 10 mm Hg increments up to 80 mm Hg and then deflated suddenly.

Abbreviations: EF, ejection fraction; EV, ejection volume; IPMIV, incremental pressure causing the maximum increase in calf volume; OF, outflow fraction; OV, total outflow volume; OV1, outflow volume in 1 second; VDI, venous drainage index; VDT, venous drainage time; VFI, venous filling index; VFT, venous filling time; wVV, working venous volume.

From reference 23: Lattimer CR et al. Eur J Vasc Endovasc Surg. 2016;52(1):105-112. © 2016, European Society for Vascular Surgery.

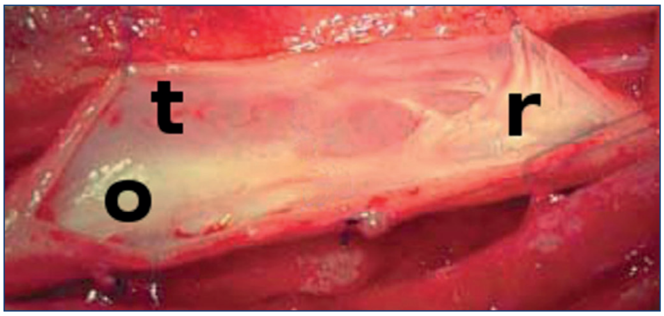

Figure 5. A femoral vein opened during surgery, demonstrating postthrombotic fibrosis.

The valve is contracted causing reflux (r), there is an obstruction to the flow (o), and the vein is lined with scar tissue resulting in a reduction in tone (t).

Figure 6. Three patients with discomfort, gaiter pigmentation, some edema, and a little reflux on ultrasound.

Do any of these legs have a drainage insufficiency?

The final parameter to change meaning is the venous volume, which has been renamed as the working venous volume *(Figure 4)*. It is the change in calf volume from a position of elevation to dependency (or vice versa). Using the original venous volume term is not accurate because the measured parameter is not the total venous volume of the calf. Patients with venous obstruction require high venous pressures for drainage, resulting in a leg that does not drain completely on elevation. It is only when the obstruction is released with a venous stent that this reserve volume is realized, and this is termed the drainage reserve volume in mL.[32] The working venous volume + drainage reserve volume = venous volume. An elevated working venous volume in a nonobstructed patient quantifies venous pooling, especially when compared with the contralateral normal leg.

New parameters

The venous drainage index (VDI) is the main recent advance in APG *(Figure 4)*. It is the mirror opposite of the venous filling index (VFI) and both are measured in mL/s for comparative evaluation.[33] Trendelenburg first realized that gravitational maneuvers were important in venous assessment[34]; JC Allan first demonstrated these on a tilt table using APG[35] and now the rate of filling and drainage can be quantified digitally.[36] This parameter has been validated extensively for use in the quantification of venous obstruction.[37] It is responsive to stenting[38] and experimental obstruction[32] using an inflatable thigh cuff set at predetermined inflation pressures. It could be argued that the VFI and VDI are the most important measurements in assessing venous insufficiency in contrast to ultrasound findings in individual veins. Furthermore, the measurements are global and just record the change in calf volume. These measurements may be more relevant than measurements of reflux or diameter. Dependency maneuvers reflect that venous disease is a failure of our defense mechanisms against gravity. They are independent of the patient's ability to contract muscles or the investigators skill at compressing the calf.

The incremental pressure causing the maximal increase in calf volume (IPMIV) is the main response of the calf to a 10 mm Hg stepwise increase in thigh cuff inflation pressures.[29] It is a venous occlusion plethysmography parameter that is related to venous tone *(Figure 4)*. This parameter has also been used to test the threshold pressure at which a graduated elastic compression stocking fails to prevent calf expansion.[29]

Reference values

The normal reference values for dependent venous filling (VFI) and elevation drainage (VDI) depend on the size of the sensor cuff and calf, the range of postural change and the speed of this change. For example, the venous drainage time cannot be less than the time taken to elevate the leg. In consequence, there is a grey zone where subjects may have a borderline value. Small thin patients will have a reduced VFI in comparison to tall patients with a wide calf. Furthermore, all results should be interpreted in the context of the build of the patient. Comparing the results to the normal contralateral leg is very helpful as well as standardising the results by scaling the values against an adjusted vWW of 100mL. As an indicator for a normal sized Caucasian person the VFI should be <2.0 mL/s. Regarding elevation drainage, a VDI value >16 mL/s, a drainage time < 6 seconds with a straight-line appearance of the drainage line and an abrupt termination point would exclude significant central venous obstruction. A VDI <8 mL/s is indicative of venous occlusion. Unfortunately, clinical symptoms and signs may not help to determine cut-off values defining significant disease because of the lack of significant correlations between symptoms and signs as well as the lack of their correlation with haemodynamic values.

Superficial venous disease

Diagnosis

It is often not apparent from taking a history and examining a leg with duplex ultrasound that the patient has venous insufficiency; for example:

- The patient with nonspecific leg symptoms and C_1 disease, and, other than the mild pitting edema present in all adults who stand for too long (occupational edema), may have very little reflux on ultrasound. Would treatment of the mild reflux improve the patient?
- In the UK, treatments for superficial venous disease are not permitted for cosmetic reasons alone. The objectives are not lesion-based, but symptom-based with the presence of any reflux. Is this reflux significant?
- Would treatment of a mildly refluxing saphenous trunk be advised in a patient with lymphedema?
- Patients with gaiter pigmentation and again little apparent reflux on ultrasound *(Figure 6)*.

In the four examples above, if the VFI was not elevated, this would discourage interventional treatment because the diagnosis is not likely to be venous.

Quantification

Patients with comorbidities, such as diabetes, arthritis, back pain, and cardiac impairment may also have venous disease. Quantification of the amount of insufficiency with the VFI may help determine its significance. Assessments with duplex ultrasound are qualitative and usually performed using a pumping maneuver of the calf. Significant reflux may be missed; for example, a refluxing anterior accessory saphenous vein or refluxing perforating vein. Not only does the VFI serve as a quality control check on the hemodynamic significance of the ultrasound findings, but it can give an answer to how much.

Outcomes

Currently, ultrasound outcomes do not represent incomes. For example, the pre-op diagnosis is based on reflux, the treatment is based on the presence of an occlusion, and the ideal end point should be restoration of competency. If the wrong vein is ablated inadvertently, then the ultrasound success of occlusion will still be present. Quantifying the insufficiency before and after with the VFI in mL/s has the advantage of reconciling incomes with outcomes. In this way, the phlebologist will have objective feedback on how well the leg has been treated.

Discord outcomes

Treatment success could be defined as a significant improvement in three domains: QOL, clinical severity, and reduction in the insufficiency. A full house where all three improve is not always the case. A discord is defined in the other 6 (out of 7) possibilities of the Venn diagram *(Figure 7)*. The VFI is an essential component of a discord outcome analysis.[39] Typical discords include an improvement in the VCSS and the VFI, but deterioration in the AVVQ. Another discord is an improvement in the AVVQ and VCSS, but deterioration in the VFI. A discord outcome analysis interrogates the process from diagnosis to follow-up with the aim of providing transparency in clinical trials,[39] which may be a first step in improving appropriateness in interventional treatments.[40]

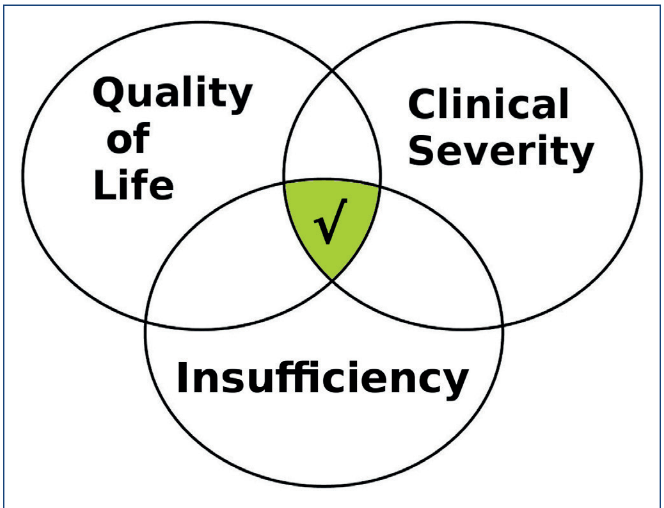

Figure 7. The discord outcome analysis comprises three outcome domains illustrated as a Venn diagram.

A global success (central tick mark) occurs with a significant improvement in all three domains. The other six possibilities are discord outcomes.

From reference 39: Kalodiki E et al. Eur J Vasc Endovasc Surg. 2019;57(2):247-274. © 2018, European Society for Vascular Surgery.

Deep venous disease

Screening test

On rapid leg elevation, the venous blood in the calf should discharge like a waterfall. The behavior should be likened to a falling column of fluid. This is a resistance free flow without a pressure–volume relationship and is apparent as a drainage line on the APG tracing (in contrast to the outflow curve seen with venous occlusion plethysmography). With increasing obstruction, this line changes to a curve with a decrease in the VDI and an increase in the drainage time *(Figure 8)*.[32] The VDI has become the gold-standard test in the assessment of obstruction. It is gravitational, fast, and it does not rely on the recoil of congested calf blood issuing into empty thigh veins caused by the occlusion cuff (as it does in venous occlusion plethysmography). The necessity of screening for deep venous disease is debatable; however, missing deep venous disease can result in great morbidity, including venous leg ulceration. Pelvic ultrasound is operator dependent and insufficient for diagnosis in most patients, contrast venography is not without radiation exposure and renal toxicity, and intravenous ultrasound is invasive. Outpatient APG may provide all the information and prevent the need for further investigations.

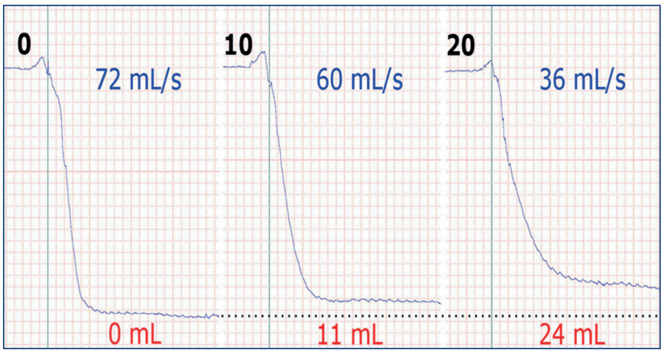

Figure 8. Volume versus time tracings demonstrating the effect of increasing thigh cuff compression pressures (0 mm Hg to 10 mm Hg to 20 mm Hg) on obstructing elevation drainage.

The venous drainage index decreases (blue) and the drainage reserve volume increases (red) with increasing obstruction.

From reference 32: Lattimer CR et al. J Vasc Surg Venous Lymphat Disord. 2017;5:88-95. © 2017, Society for Vascular Surgery.

Significance of imaging

Imaging is anatomical and assesses individual veins. Perhaps the best imaging modality is the injection of contrast directly into both femoral thigh veins with reconstruction views. However, if collaterals are observed, then the debate arises as to whether they are sufficient to

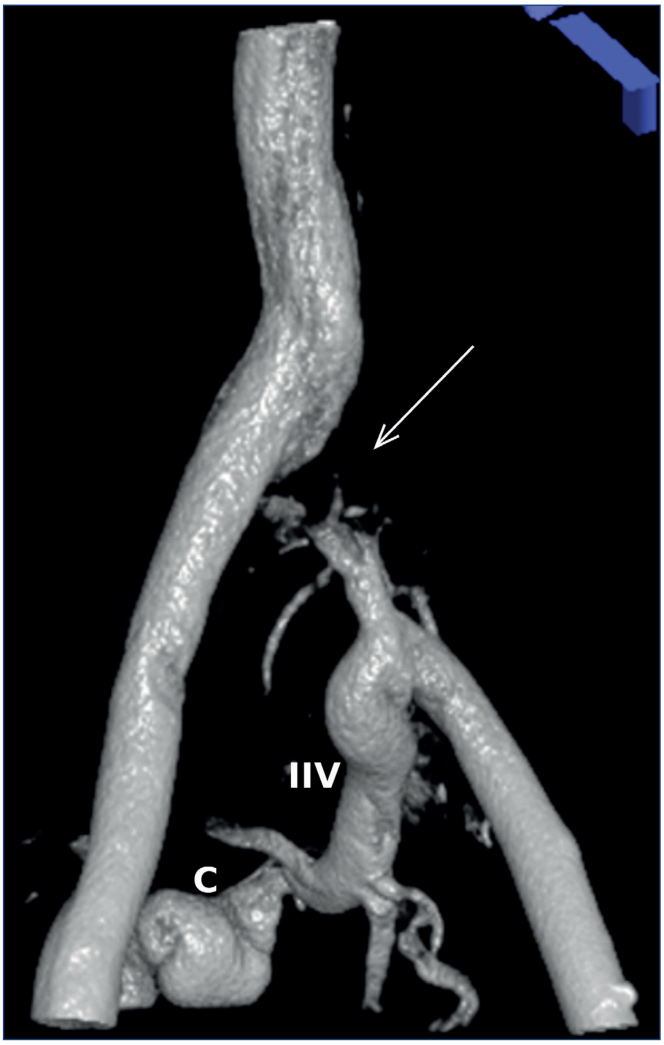

Figure 9. Surface-shaded CT venogram performed with direct bilateral femoral vein contrast injection.

The left common iliac vein is occluded (arrow). Left limb drainage is via the internal iliac vein (IIV) and collaterals (C) and then into the right common iliac vein. Are these large long-standing collaterals sufficient to drain the leg or are they just an expression of the severity of the obstruction?

drain the leg or just a marker of severe disease *(Figure 9)*. Furthermore, a >50% iliac vein compression occurs in 24% of the normal population[40] and posture will influence the degree of collapse,[36,42] as well as the size and shape of any suspected target for intervention. Functional testing with APG may help in the interpretation of images.

Inappropriate stenting

If the clinical symptoms and signs fit and a lesion is identified (usually >50% reduction in diameter[43]), then the patient may go on to have a venous stent, which is for life. Understandably, many patients do not improve clinically. The purpose of APG is to determine if there is a significant obstruction present in the first place and to determine if the stent has worked in its aim to improve the elevation drainage using the VDI. The interventionalist, who may never see the patient outside of the angio suite, needs to know how well the lesion has been treated and a VDI may help. Regarding a successful intervention, a discord outcome analysis may be used.[39] The identification of hemodynamic improvement, but clinical deterioration or vice versa induces an interrogation about the management of that patient. It should help improve appropriateness and ethics in stenting patients for deep venous obstruction.[44]

Mixed venous disease

In patients with combined pelvic venous obstruction and superficial venous reflux, there is controversy as to which system to treat first. Stenting a significant obstruction reduces symptoms and venous pressure allowing the

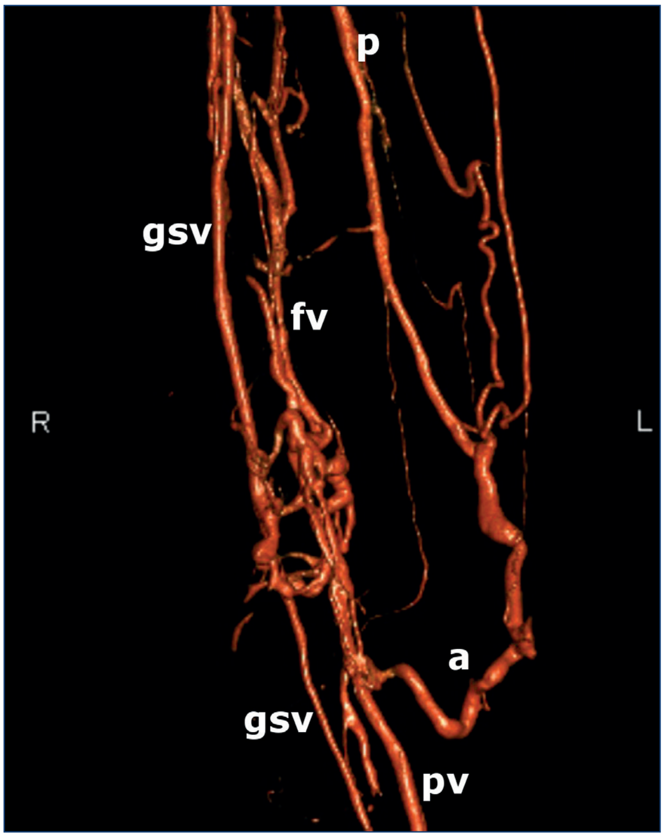

Figure 10. Lower thigh venogram reconstruction of a femoral vein (fv) obstruction demonstrating poor recanalization and perivenous collateralization.

The popliteal vein (pv) now drains into the profunda femoris vein (p) from a collateral (a) (termed axialization). The great saphenous vein (gsv) also drains the leg. It is dilated in its upper part to accommodate the increase in drainage volume from the popliteal vein (pv) or is it dilated from reflux? Would great saphenous vein ablation help this patient?

superficial system to recover. Alternatively, treating the reflux first is less invasive and technically easier. If the patient improves significantly, the obstruction may not have been as severe as originally proposed. In this case, the deep venous disease will not need treating.

A different situation is one of combined femoral vein obstruction and great saphenous vein reflux in patients with postthrombotic syndrome. The controversy here is whether the saphenous vein should be ablated, as it may be an important drainage route bypassing the femoral obstruction. If there is axial drainage of the popliteal vein via profunda vein collaterals (axial transformation), then improvement would be expected with great saphenous vein ablation. However, without APG, contrast venography is often required to establish the anatomy and predict the response to superficial ablation *(Figure 10)*. In both situations, the VFI and the VDI are useful because they quantify filling and drainage and express them in the same units (mL/s) for comparative assessment. In the second case of femoral obstruction, the great saphenous vein can be occluded with a duplex probe to predict the hemodynamic effect of ablation *(Figure 11)*.

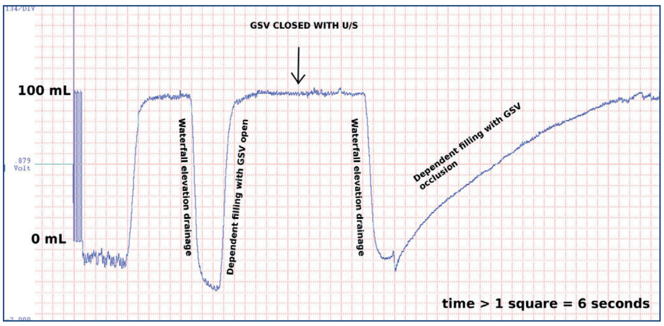

Figure 11. The digital calf volume versus time tracing of APG on a tilt table.

Occlusion of the GSV with the ultrasound probe (arrow) had no effect on the elevation drainage of this leg, but it decreased the filling rate substantially. GSV ablation is anticipated to have a beneficial effect in this patient.

Abbreviations: APG, air plethysmography; GSV, great saphenous vein.

It has been proposed that varicose veins may be the result of iliac vein compression,[45] in the same way any biological tube dilates proximal to an obstruction. The use of APG showed that this was not the case. Gravitational drainage on leg elevation was faster with a higher VDI compared with healthy controls without varicose veins.[33] The explanation given was that larger draining veins contained more blood. This knowledge is useful for patients with combined pelvic obstruction and varicose veins because any real obstruction may be offset by improved elevation drainage from the varicose veins. A reduced VDI threshold in these patients would be required for a diagnosis of obstruction.

Summary

APG offers an objective assessment of all the main causes of venous insufficiency, with VFI and VDI being the most useful parameters. The test does not require radiation exposure, contrast, or vein puncture. In contrast to the questionnaires, which are research tools, APG is a clinical instrument providing useful information to rationalize the relationship between symptoms and signs, direct treatment, and quantify outcomes. Its ease of use, portability, and value places APG out of the vascular laboratory and into the outpatient setting. In conclusion, all patients need to be investigated with APG whenever venous insufficiency is suspected.

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REFERENCES

1. Evans CJ, Fowkes FG, Ruckley CV, Lee AJ. Prevalence of varicose veins and chronic venous insufficiency in men and women in the general population: Edinburgh Vein Study. *J Epidemiol Community Health.* 1999;53:149-153.
2. Evans CJ, Allan PL, Lee AJ, Bradbury AW, Ruckley CV, Fowkes FG. Prevalence of venous reflux in the general population on duplex scanning: the Edinburgh vein study. *J Vasc Surg.* 1998;28:767-776.
3. Bradbury A, Evans C, Allan P, Lee A, Ruckley CV, Fowkes FG. What are the symptoms of varicose veins? Edinburgh vein study cross sectional population survey. *Br Med J.* 1999;318:353-356.
4. Blattler W, Thomae HJ, Amsler F. Venous leg symptoms in healthy subjects assessed during prolonged standing. *J Vasc Surg Venous Lymphat Disord.* 2016;4:455-462.
5. Van der Velden SK, Shadid NH, Nelemans PJ, Sommer A. How specific are venous symptoms for diagnosis of chronic venous disease? *Phlebology.* 2014;29:580-586.
6. Amsler F, Rabe E, Blattler W. Leg symptoms of somatic, psychic, and unexplained origin in the population-based Bonn vein study. *Eur J Vasc Endovasc Surg.* 2013;46:255-262.
7. Blaettler W, Amsler F, Mendoza E. The relative impact on leg symptoms of fears of getting varicose veins and of great saphenous vein reflux. *Phlebology.* 2013;28:347-352.
8. Obermayer A, Garzon K. Identifying the source of superficial reflux in venous leg ulcers using duplex ultrasound. *J Vasc Surg.* 2010;52:1255-1261.
9. Hareendran A, Bradbury A, Budd J, et al. Measuring the impact of venous leg ulcers on quality of life. *J Wound Care.* 2005;14:53-57.
10. Yim E, Vivas A, Maderal A, Kirsner RS. Neuropathy and ankle mobility abnormalities in patients with chronic venous disease. *JAMA Dermatol.* 2014;150:385-389.
11. Smith JJ, Garratt AM, Guest M, Greenhalgh RM, Davies AH. Evaluating and improving health-related quality of life in patients with varicose veins. *J Vasc Surg.* 1999;30:710-719.
12. Rutherford RB, Padberg FT Jr, Comerota AJ, Kistner RL, Meissner MH, Moneta GL. Venous severity scoring: An adjunct to venous outcome assessment. *J Vasc Surg.* 2000;31:1307-1312.
13. Aber A, Poku E, Phillips P, et al. Systematic review of patient-reported outcome measures in patients with varicose veins. *Br J Surg.* 2017;104:1424-1432.
14. Eklof B, Rutherford RB, Bergan JJ, et al. Revision of the CEAP classification for chronic venous disorders: consensus statement. *J Vasc Surg.* 2004;40:1248-1252.
15. Lattimer CR, Kalodiki E, Azzam M, Geroulakos G. Responsiveness of individual questions from the venous clinical severity score and the Aberdeen varicose vein questionnaire. *Phlebology.* 2014;29:43-51.
16. Villalta S, Bagatella P, Piccioli A, Lensing A, Prins M, Prandoni P. Assessment of validity and reproducibility of a clinical scale for the post-thrombotic syndrome (abstract). *Haemostasis.* 1994;24:158a.
17. Trinh F, Paolini D, Fish J, Kasper G, Lurie F. Use of Villalta score for defining post-thrombotic disease may lead to false-positice diagnosis in 42% of patients with primary chronic venous disease. *J Vasc Surg Venous Lymphat Disord.* 2018;6:291.
18. Delis KT, Bountouroglou D, Mansfield AO. Venous claudication in iliofemoral thrombosis: long-term effects on venous hemodynamics, clinical status, and quality of life. *Ann Surg.* 2004;239:118-126.
19. Kurstjens RL, van Vuuren TM, de Wolf MA, de Graaf R, Arnoldussen CW, Wittens CH. Abdominal and pubic collateral veins as indicators of deep venous obstruction. *J Vasc Surg Venous Lymphat Disord.* 2016;4:426-433.
20. Raju S, Ward M Jr, Jones TL. Quantifying saphenous reflux. *J Vasc Surg Venous Lymphat Disord.* 2015;3:8-17.
21. Lattimer CR, Azzam M, Kalodiki E, Geroulakos G. Quantifying saphenous recirculation in patients with primary lower extremity venous reflux. *J Vasc Surg Venous Lymphat Disord.* 2016;4:179-186.
22. Vaccaro AR, Kepler CK, Rihn JA, et al. Anatomical relationships of the anterior blood vessels to the lower lumbar intervertebral discs: analysis based on magnetic resonance imaging of patients in the prone position. *J Bone Joint Surg Am.* 2012;94:1088-1094.
23. Lattimer CR, Kalodiki E, Azzam M, Geroulakos G. Haemodynamic performance of low strength below knee graduated elastic compression stockings in health, venous disease, and lymphoedema. *Eur J Vasc Endovasc Surg.* 2016;52(1):105-112.
24. Raju S, Kirk O, Davis M, Olivier J. Hemodynamics of "critical" venous stenosis and stent treatment. *J Vasc Surg Venous Lymphat Disord.* 2014;2:52-59.
25. Kurstjens RLM, de Wolf MAF, Alsadah SA, et al. The value of hemodynamic measurements by air plethysmography in diagnosing venous obstruction of the lower limb. *J Vasc Surg Venous Lymphat Disord.* 2016;4:313-319.
26. Kurstjens RL, Catarinella FS, Lam YL, de Wolf MA, Toonder IM, Wittens CH. The inability of venous occlusion air plethysmography to identify patients who will benefit from stenting of deep venous obstruction. *Phlebology.* 2018;33:483-491.
27. Clarke H, Smith SR, Vasdekis SN, Hobbs JT, Nicolaides AN. Role of venous elasticity in the development of varicose veins. *Br J Surg.* 1989;76:577-580.
28. Geroulakos G, Nicolaides A. Venous tone evaluation by elastic modulus and therapeutic implications. *Int Angiol.* 1995;14:14-17.
29. Lattimer CR, Kalodiki E, Kafeza M, Azzam M, Geroulakos G. Quantifying the degree graduated elastic compression stockings enhance venous emptying. *Eur J Vasc Endovasc Surg.* 2014;47:75-80.
30. Lattimer CR, Franceschi C, Kalodiki E. Optimizing calf muscle pump function. *Phlebology.* 2018;33:353-360.
31. Franceschi C. Measures and interpretation of venous flow in stress tests. Manual compression and Parana manoeuver. Dynamic reflux index and Pstakis index [article in French]. *J Mal Vasc.* 1997;22:91-95.
32. Lattimer CR, Doucet S, Geroulakos G, Kalodiki E. Validation of the novel venous drainage index with stepwise increases in thigh compression pressure in the quantification of venous obstruction. *J Vasc Surg Venous Lymphat Disord.* 2017;5:88-95.
33. Lattimer CR, Kalodiki E, Mendoza E. Gravitational venous drainage is significantly faster in patients with varicose veins. *Phlebology.* 2016;31:546-553.
34. Trendelenburg F. Ueber die unterbindung der vena saphena magna bei unterschenkelvaricen. *Beitr Klinishen Chir.* 1891;7:195-210.
35. Allan JC. Volume changes in the lower limb in response to postural alterations and muscular exercise. *S Afr J Surg.* 1964;2:75-90.
36. Lattimer CR, Mendoza E. Reappraisal of the utility of the tilt-table in the investigation of venous disease. *Eur J Vasc Endovasc Surg.* 2016;52:854-861.
37. Lattimer CR, Mendoza E, Kalodiki E. The current status of air-plethysmography in evaluating non-thrombotic iliac vein lesions. *Phlebology.* 2018;33:3-4.

REFERENCES

38. Lattimer CR, Kalodiki E, Azzam M, Schnatterbeck P, Geroulakos G. Gravitational venous drainage improves significantly after iliac venous stenting but this may result in faster venous filling. *J Vasc Surg Venous Lymphat Disord.* 2016;4:137-138.

39. Kalodiki E, Azzam M, Schnatterbeck P, Geroulakos G, Lattimer CR. The discord outcome analysis (DOA) as a reporting standard at three months and five years in randomised varicose vein treatment trials. *Eur J Vasc Endovasc Surg.* 2019;57(2):247-274.

40. Lawrence PF. "Better" (sometimes) in vascular disease management. *J Vasc Surg.* 2016;63:260-269.

41. Kibbe MR, Ujiki M, Goodwin AL, Eskandari M, Yao J, Matsumura J. Iliac vein compression in an asymptomatic patient population. *J Vasc Surg.* 2004;39:937-943.

42. Kamm RD, Pedley TJ. Flow in collapsible tubes: a brief review. *J Biomech Eng.* 1989;111:177-179.

43. Gagne PJ, Gasparis A, Black S, et al. Analysis of threshold stenosis by multiplanar venogram and intravascular ultrasound examination for predicting clinical improvement after iliofemoral vein stenting in the VIDIO trial. *J Vasc Surg Venous Lymphat Disord.* 2018;6:48-56 e1.

44. Passman MA. Where evidence, ethics, and professionalism converge. *J Vasc Surg Venous Lymphat Disord.* 2019;7:8-16.

45. Gaweesh AS. Impeded venous drainage: novel view of chronic venous disease pathophysiology. *Med Hypotheses.* 2009;73:548-552.

Clinical characteristics, symptoms, and quality of life evolution in outpatients with chronic venous disease treated medically or with endovascular procedures: results from the ALIADO and ALIVIO programs

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Keywords:

chronic venous disease; CEAP; CIVIQ-14; MPFF; quality of life; varices

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Abstract

The following report will discuss the results of two observational multicenter surveys–ALIADO and ALIVIO–that were carried out in outpatients with symptomatic chronic venous disease (CVD) in Colombia between 2016 and 2018 in which clinical characteristics, symptoms, and quality of life evolution were evaluated. The ALIADO program (quality of life in outpatients with CVD) evaluated patients with CVD who were seen in the framework of ordinary consultations performed by general practitioners. The ALIVIO program (endovenous ablation of varicose veins in Colombia) evaluated patients with CVD who underwent endoluminal procedures, which were performed by vascular surgeons, for the treatment of varicose veins. After a clinical examination that included the clinical, etiological, anatomical, and pathophysiological (CEAP) classification, a medical therapy was offered at the initial office visits, including phlebotonics, micronized purified flavonoid fraction in most cases, lifestyle advice, and compression therapy. Patients were followed-up in a second visit in which general practitioners evaluated both symptom evolution using the visual analog scale and quality of life evolution using the ChronIc Venous Insufficiency Quality of Life Questionnaire (CIVIQ-14) and the Global Index Score. The results showed that symptoms, including leg heaviness, pain, swelling, and cramps, and quality of life significantly improved in the follow-up visit after combining pharmacological treatment (MPFF), patient education, and compression therapy.

Introduction

Chronic venous disease (CVD) is a potentially serious common disease[1] that is frequently underestimated,[2] with a high prevalence in the adult population, especially in occidental countries.[3] Although CVD is not a life-threatening condition, it seriously affects patient's quality of life and produces loss of working days for affected patients.[4] Primary care physicians, general practitioners, and specialists, such as vascular surgeons, are concerned and both have a role in the diagnosis and treatment of patients with CVD. Two surveys–ALIADO and ALIVIO–were implemented in Colombia to observe the evolution of outpatients with CVD seeking care with general practitioners or submitted for endovascular procedures for varicose veins performed by vascular surgeons.

Methods

ALIADO was a national, observational, prospective, multicenter survey conducted between October 2016 and September 2017. CVD patients ≥18 years, regardless of the CEAP classification, consulting general practitioners, were enrolled in the study. Patient's clinical data, including quality of life measured using the ChronIc Venous Insufficiency Quality of Life Questionnaire (CIVIQ-14) questionnaire and CVD symptoms assessed using the visual analog scale (VAS), were recorded at inclusion and after a follow-up visit.

ALIVIO was implemented in adult symptomatic outpatients with CVD undergoing endovenous ablation for varicose veins performed by vascular surgeons. At inclusion, symptoms were evaluated using a 10-cm VAS and quality of life was evaluated using the CIVIQ-14 questionnaire. After the procedure, patients were asked to return for a follow-up visit at least 1 month later. During the follow-up visit, vascular surgeons assessed symptoms using VAS and quality of life using CIVIQ-14. Both surveys were approved by a local ethical committee.

The aim of the present analysis is to analyze the methodology of each survey, to present and compare the results of both surveys, and to have a global vision of chronic venous disease according to the clinical setting and the evolution of symptoms and quality of life with pharmacological treatment (micronized purified flavonoid fraction [MPFF]), lifestyle advice, and compression therapy.

Results

In ALIADO, 926 patients were included by 42 general practitioners. The mean age (±SD) was 59±14.2 years, 79% were female *(Table I)*. At inclusion, 4% of patients were in CEAP class C_0, 15% in C_1, 24% in C_2, 28% in C_3, and 30% in C_4 to C_6 *(Figure 1)*. Of the 926 patients,

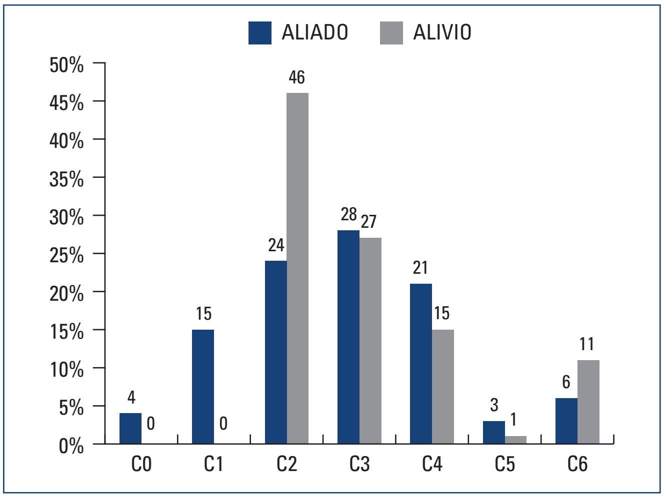

Figure 1. CEAP classification at inclusion according to each study.

97% recived MPFF, 77% lifestyle advice, and 33.6% compression therapy. In ALIVIO, 209 patients were enrolled by 12 vascular surgeons; 74% were women and the mean age (±SD) was 54±13.4 years *(Table I)*. At inclusion, 46% of the patients were in CEAP class C_2, 27% in C_3, and 27% in C_4 to C_6 *(Figure 1)*. In addition to the endovenous ablation procedure, 92% of the patients received MPFF, 81% compression therapy, and 36% lifestyle advice.

Follow-up

In ALIADO, after a mean follow-up of 87 days, symptoms decreased significantly: on average, heaviness was decreased by 58%, pain by 59%, sensation of swelling by 56%, and cramps by 55%. (all *P* values vs inclusion <0.005) *(Figure 2)*. There was a parallel improvement in quality of life, which increased 55% from 52 to 81 (*P*<0.005) *(Figure 4)*. In ALIVIO, the mean follow-up was 58.6±32.6 days, and, after this period, pain decreased by 50% (from 6.3±2.2 to 3.2±1.7 cm), swelling by 53% (from 5.7±2.5 to 2.7±1.7 cm), and cramps by 27% (5.1±2.5 to

		ALIADO			ALIVIO			GENERAL (TOTAL WEIGHTED)		
		Male	Female	General	Male	Female	General	Male	Female	General
Patients (%)	Sex	21.45%	78.55%	926 patients	26.09%	73.91%	209 patients	22.2%	77.8%	1135 patients
	Age (years)	59.88 (SD 14.9)	59.35 (SD 14.01)	59.47 (SD 14.2)	51.67 (SD 13.84)	54.55 (SD 13.2)	53.78 (SD 13.4)			
				Min 20			Min 22			
				Max 91			Max 89			

Table I. Patient characteristics between study groups.

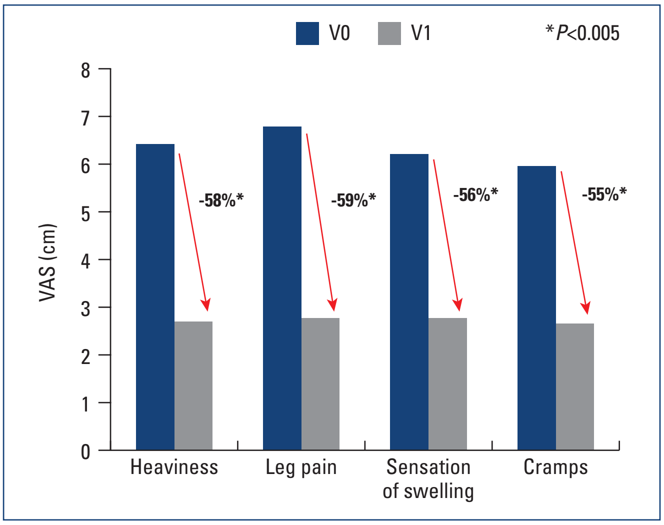

Figure 2. Symptom evaluation in the ALIADO program.

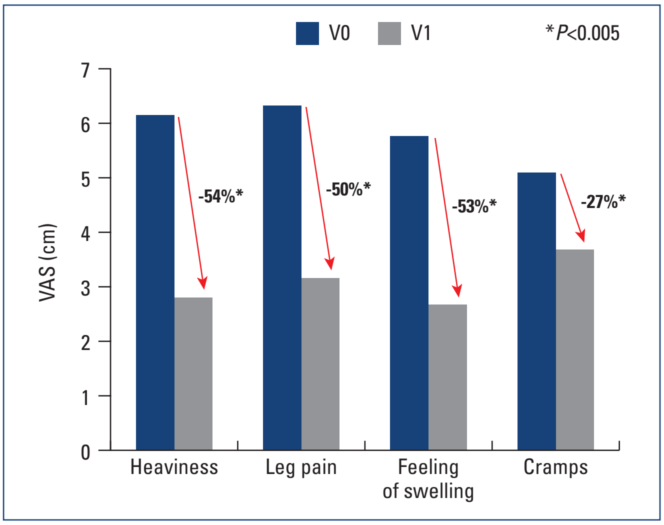

Figure 3. Symptom evolution in the ALIVIO program.

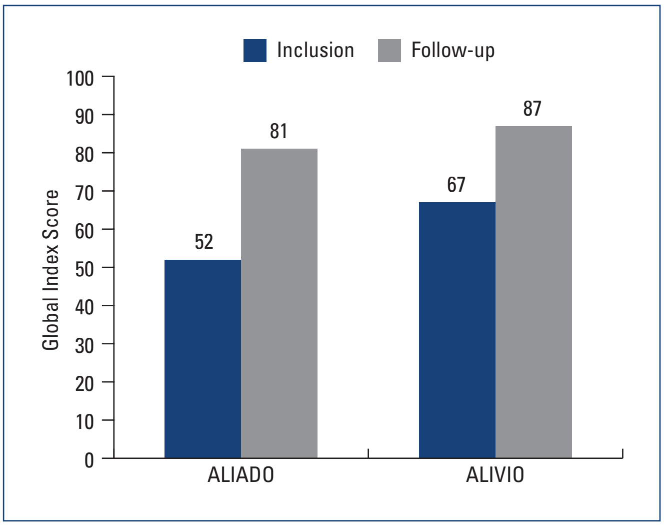

*Figure 4. Global Index Score evolution. *P<0.005 in both studies.*

3.7±2.5 cm) (all $P<0.005$) *(Figure 3)*. In terms of quality of life, all 14 items of the CIVIQ questionnaire decreased significantly (all $P<0.05$), with a parallel improvement in the Global Index Score (average increase from 67 to 87; $P<0.005$) *(Figure 4)*.

Discussion

In this paper, we presented and compared two studies conducted in Colombia in 2016 and 2018 with different methodologies and in different settings. In the first, general practitioners evaluated outpatients with symptomatic CVD, and, in the second, vascular surgeons evaluated patients with CVD who were treated with endovenous ablation for varicose veins, with 1135 patients (total between the two studies) being evaluated for the evolution of symptoms and quality of life. Although the studies were conducted in different contexts, there are common characteristics that were evaluated, such as demographics and the presence and evolution of clinical symptoms and quality of life, allowing the weighted averages to be compared. A look into the demographic data enabled us to confirm the preponderance of CVD in females; a 4:1 ratio to men in the group receiving medical treatment and a 3:1 ratio to men in the group treated with endovenous ablation of varicose veins. The average age was close to 60 years old in the medical treatment group and 6 years lower in the group treated with endovenous ablation procedures.

Regarding the reasons for consultation, we confirm that pain is the main symptom leading patients to seek medical advice (86% of cases) *(Table II)*. However, it is noteworthy that the number of patients with pain was higher among the patients seeking medical advice with general practitioners vs surgeons. It is also noteworthy that there is a high proportion of patients with telangiectasias and reticular veins, 2 patients out of 3 in the medical treatment group.

Obviously, varices were a cardinal sign present in 65% of the patients in the medical treatment group. However, it is meaningful that only 60% of patients undergoing an intervention consulted for varices, showing the importance of a good anamnesis and physical examination. During anamnesis, the cardinal symptom was leg pain, which was present in almost 90% of the patients, followed by heaviness in almost 80% of the patients and sensation of swelling and cramps in 50% of the patients. Surprisingly, these figures are higher in the medical treatment group vs the endovascular intervention group *(Table III)*. Regarding the physical examination, nearly 80% of the patients that

	ALIADO		ALIVIO		TOTAL	
Reason for consultation	Patients (n)	%	Patients (n)	%	Patients (n)	%
Pain, heaviness, sensation of swelling, burning cramps	860	87.04	120	57.42	980	86.39
Telangiectasias	669	72.25	71	33.97	740	65.19
Varicose veins	610	65.87	127	60.77	737	64.93
Edema	454	49.03	47	22.49	501	44.14
Skin changes	202	21.87	39	18.66	241	21.23
Ulcer	76	8.21	24	11.48	100	8.81

Table II. Reasons for consultation between study groups showing the noncumulative percentages; each patient can have more than one.

	ALIADO			ALIVIO		
Symptom	**Patients (n)**	**%**	**Values by VAS (cm) mean±SD**	**Patients (n)**	**%**	**Values by VAS (cm) mean±SD**
Heaviness	693	74.84%	6.36±1.95	173	82.78%	6.14±2.14
Leg pain	875	94.49%	6.71±2.1	182	87.08%	6.31±2.26
Sensation of swelling	579	62.53%	6.17±2.11	104	49.76%	5.74±2.46
Cramps	573	61.88%	5.91±2.3	122	53.59%	5.09±2.46

Table III. Symptoms in anamnesis (4 weeks before inclusion) showing the noncumulative percentages.

consulted a general practitioner presented clear signs of CVD and only 20% did not present evident clinical signs (4% were in CEAP class C_0 and 15% in CEAP class C_1).

Less than a half of patients treated with endovascular procedures (46%) had varices, where the main sign was edema (27%). In the other patients (27%), the procedure was done due to skin changes in the ulcers (active or healed). There was an important reduction in symptoms after treatment. In the medical treatment group, which included lifestyle advice, compression therapy in some patients, and pharmacological treatment in most, 92% of patients were asymptomatic or rarely symptomatic. There was also a decrease in the presence of symptoms in the group treated with endovascular procedures, where 42% of patients were asymptomatic or rarely symptomatic during the follow-up *(Table IV)*. Both studies showed a significant reduction (more than 50%) in heaviness, pain, and the sensation of swelling. However, there is an unexplained low decrease (27%) in cramps in the endovascular treatment group. Finally, there is a significant improvement in the quality of life in both groups, keeping in mind that these are different cohorts and not strictly comparable.

	ALIADO	ALIVIO
Inclusion: regularly or occasionally	78%	88%
Follow-up: regularly or occasionally		38%
Follow-up: rarely or never	92%	42%

Table IV. Frequency of symptoms.

Conclusions

We have confirmed the higher prevalence of CVD in females who consult for symptoms of CVD to both vascular surgeons and general practitioners than in men. Pharmacological treatment with MPFF, compression therapy, and lifestyle advice should be part of the medical treatment for patients who are treated noninvasively and for those who are treated with minimally invasive procedures to provide a significant improvement in symptoms and a parallel improvement in quality of life.

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REFERENCES

1. Bergan JJ, Schmid-Schönbein GW, Smith PD, Nicolaides AN, Boisseau MR, Eklof B. Chronic venous disease. *N Engl J Med.* 2006;355(5):488-498.

2. Van den Oever R, Hepp B, Debbaut B, Simon I. Socio-economic impact of chronic venous insufficiency. An underestimated public health problem. *Int Angiol.* 1998;17(3):161-167.

3. Brand FN, Dannenberg AL, Abbott RD, Kannel WB. The epidemiology of varicose veins: the Framingham Study. *Am J Prev Med.* 1988;4(2):96-101.

4. Nicolaides A, Kakkos S, Eklof B, et al. Management of chronic venous disorders of the lower limbs - guidelines according to scientific evidence. *Int Angiol.* 2014;33(2):87-208.

Intravascular ultrasound: technique, provided information, and indications

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Abstract

The aim of this article is to convince phlebologists that intravascular ultrasound (IVUS) eases and improves the making of venoplasty and stenting of iliac and caval vein obliterations. First, the article will describe the IVUS system, ie, it is a system containing a probe catheter, a control, and a tower and it records data. Then, the article will discuss the procedure technique in depth from probe insertion and positioning up to the segment to be examined and the slow pull back from the proximal to the distal site. Lumen measurements are made on recorded images. Finally, this article will detail the information provided by IVUS, including how this investigation is crucial for stent choice, positioning, deployment, and postprocedural control.

Keywords:

intravascular ultrasound; outflow obstruction; vein stenting; venography; venous ultrasound

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www.phlebolymphology.org

Introduction

In recent years, the endovascular technique, by means of venoplasty and stenting, has become the first-choice interventional treatment for outflow obstruction in patients affected by chronic venous insufficiency caused by postthrombotic syndrome or a primary obstruction (nonthrombotic iliac vein lesions).

After the first series of vein stenting in chronic outflow obstruction, published by Neglen et al,[1,2] the angioplasty/stenting technique in veins has been progressively ameliorated and finally standardized. More recently, new venous-dedicated stents have been delivered to the market, thus providing a possible solution for many of the issues related to the specific venous system characteristics. Moreover, data regarding the clinical outcomes after outflow obstruction correction are available today.[3,4] In a recent review of the literature, significant clinical improvements in chronic venous insufficiency severity were detected by evaluating both validated measurement scores and venous disease–specific quality of life; even if the quality of evidence indicating outflow obstruction treatment is still weak, the procedure is very promising and safe.[5]

Nowadays, it can be stated that venoplasty is a well-consolidated procedure in terms of both technical knowledge and expected clinical results. On the other hand, patient selection for outflow obstruction treatment is still a critical issue. In fact, quantifying the hemodynamic role of vein stenosis is currently not possible: a resistance index has still not been validated, and, consequently, we can measure an anatomic degree of stenosis and not the entity of obstruction. This limit appears to be stronger when a primary obstruction has to be confirmed or excluded. Thus, indication for treatment is mainly based on the clinical assessment of the patient and on diagnostic imaging (venography, venous CT, venous MRI). Historically, venography has been considered the gold-standard diagnostic method in identifying chronic deep venous alterations, while CT and MRI still present some difficulties in both feasibility and interpretation. The role of intravascular ultrasound (IVUS) in the examination of deep veins was identified at the very beginning of the interventional endovenous experience.[6] Moreover, subsequent experiences showed its possible superiority over venography.[7] In fact, while venography is essentially multiplanar, IVUS gives a full circumferential view of the vein lumen, thus it is adapted better for the elliptical and flattened shape of the vein lumen. In postthrombotic syndrome, the endovenous and parietal fibrotic damage is clearly shown by IVUS, meaning that the anatomic complexity, webs, spurs, and double channels, etc, are easily detectable so that the full extension of the lesion can be identified and treated. In order to define the real role of IVUS in the diagnosis and treatment of outflow obstruction better, a trial has been undertaken. The VIDIO study (Venogram Versus Intravascular Ultrasound for Diagnosing and Treating Iliofemoral Vein Obstruction) was a multicenter, prospective, single-arm study that enrolled 100 patients and compared IVUS and multiplanar venography. IVUS proved to be significantly more sensitive than multiplanar venography in identifying and characterizing venous stenosis, changing the treatment plan in 57 out of 100 patients.[8] Despite these good results, leading to defining IVUS as the gold-standard technique in obstruction treatment,[9] data regarding possible improved clinical outcomes due to this diagnostic application are still required in order to set IVUS as a mandatory procedure even if this is already happening in daily practice.

Technique

System

At present, the available IVUS system is the Visions System (Philips Volcano), which consists of a tower equipped with a disposable ultrasound probe. The transducer utilizes a 64-element cylindrical array, which is placed circumferentially on the tip of a disposable over-the-wire probe, generating real-time imaging. The catheter probe usually utilized in veins works on a 0.035" platform and requires a minimum 9 Fr indwelling sheath. Radiopaque markers at 1-cm distances are present over 20 cm of the catheter-shaft length *(Figure 1)*.

IVUS gives B-mode, low-resolution imaging, without a coupled spectrum analysis, meaning that we can obtain morphologic and anatomic information with this technique, but not data regarding flow. The widest window using 0.035" probe is 6 cm. Usually, this width allows the contents and the wall of the vessel the probe is in and some of the closer structures to be examined *(Figure 2)*. When the probe is placed in the inferior cava, considering that the diameter

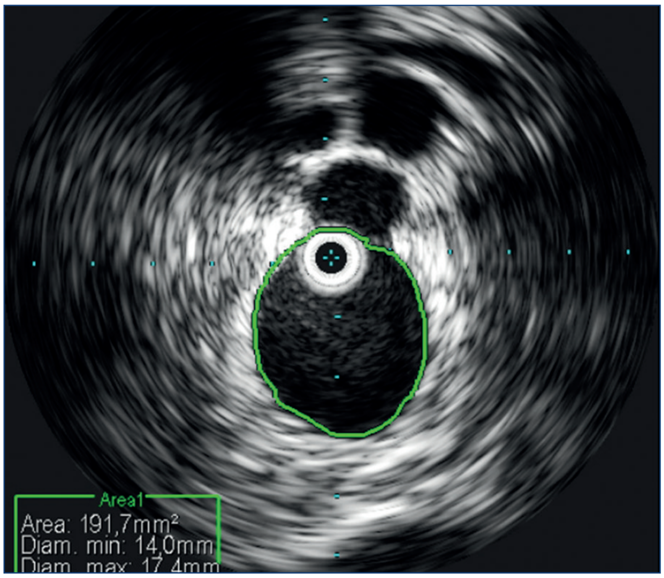

Figure 1. IVUS 0.035 probe tip.
Radiopaque markers are clearly visible over the catheter.

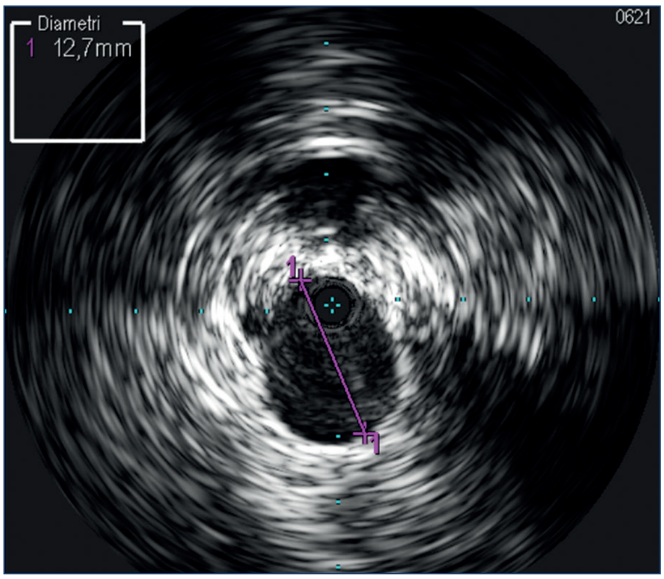

Figure 2. A probe inserted into the common iliac vein, where the width of the window (diameter) is a maximum of 6 cm.

rarely exceeds 3 cm, the vessel can be seen completely. Poor information is given about the surrounding tissues, even if some tissues, such as the liver are clearly identified *(Figure 3)*. The probe catheter is connected to the tower using a specific probe connector hooked to the angiosuite bed. Patient data should be registered in order to proceed to examination and recording. Operations on the tower keyboard can be done by the surgeon himself using a sterile keyboard cover or by a nonscrubbed technician.

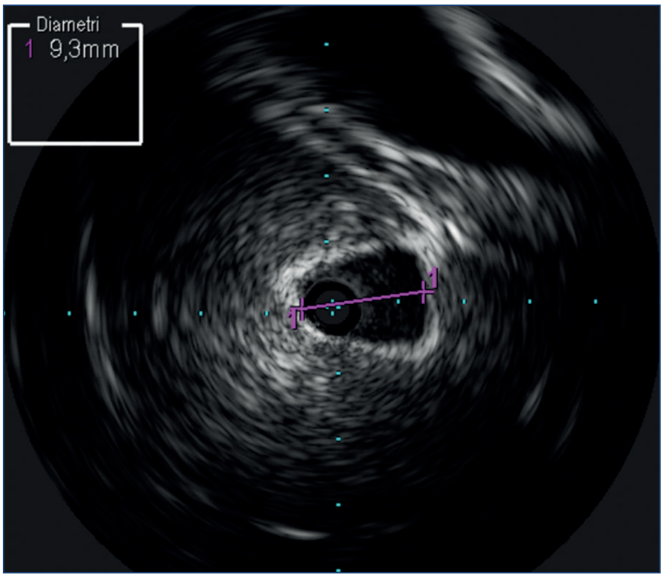

Figure 3. A probe inserted into the inferior cava at the hepatic level.

The typical echogenicity of hepatic tissue is clearly visible.

Exam

In procedures for the treatment of outflow obstruction, the cava and the iliofemoral segment should be examined. The probe is inserted over a wire, preferably stiff, and pushed up to the district to be examined. The access site can be popliteal, jugular, or more frequently, femoral. Navigation proves quite easy due to a low profile tip, while the torsion control is poor. It is sometimes difficult to maintain a stable orientation of the probe. In order to avoid imaging artifacts around the probe, the "ring down maneuver" should be performed. This maneuver corresponds to a still image captured in a complete hypoecogenic area (blood) around the probe tip. Usually the probe tip should be in the right atrium during venous examinations in order to obtain a good reduction in the number of artifacts *(Figure 4)*. Once the ring-down maneuver is performed, it will remain effective until the probe is connected to the tower, so the whole procedure can be done with a single ring-down, even if the probe is taken out of the vessel and inserted again.

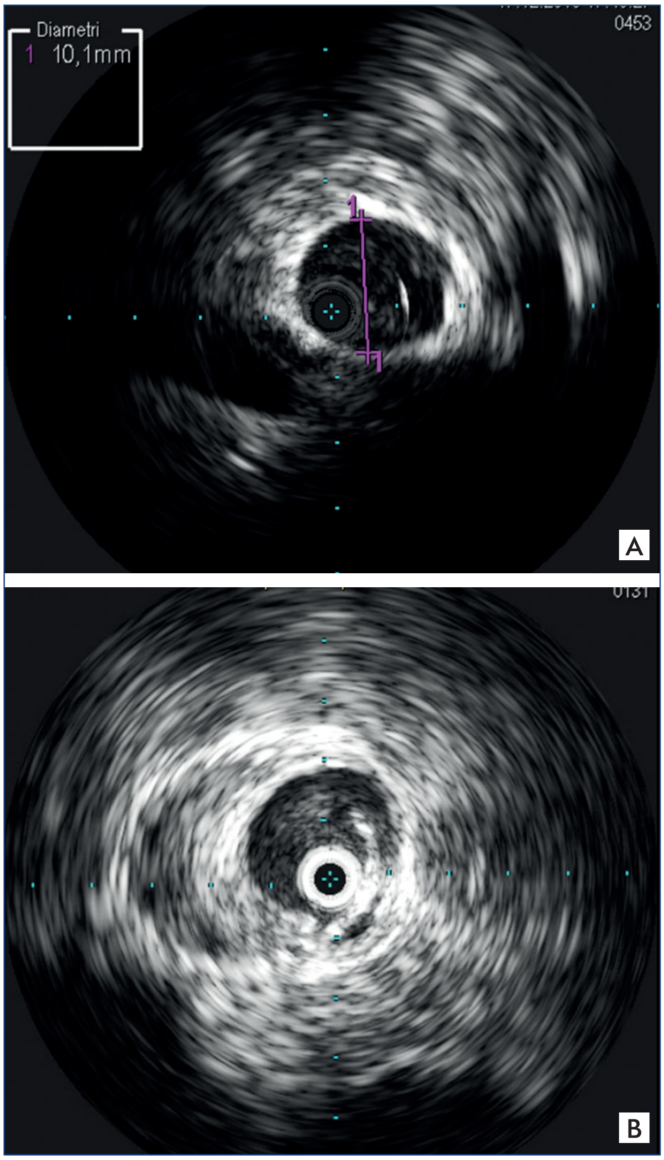

Figure 4. Ring-down maneuver for reducing imaging artifacts.

Panel A. The ring-down maneuver has been performed and the probe is visible in the vein lumen as a black/grey dot without artifacts.

Panel B. The ring-down maneuver has not been performed, as is visualized by the echogenic artifacts present as a white ring, thereby limiting the vessel wall analysis.

To proceed with the examination, the probe is placed up to the segment to be examined and then a craniocaudal pullback maneuver is performed, usually with simultaneous registration. To obtain an exhaustive imaging set and a better postprocessing of the registered exam, the pullback maneuver should be slow. Measurements can be done on the recorded images, selecting the adequate image. The lateral bar, which gives a longitudinal view of the explored vessel, cannot be used to take longitudinal measurements because the manual pullback maneuver is not standardized and consequently image acquisition is not at a defined distance.

Provided information

IVUS imaging provides quite clear images of the vessel wall and of the vessel content, even if higher-resolution imaging would be helpful. The vessel wall structure *(Figure 5)*, the lumen shape *(Figure 6)*, and the vessel content are clearly shown. In patients with postthrombotic syndrome, the intraluminal fibrosis is very irregular and

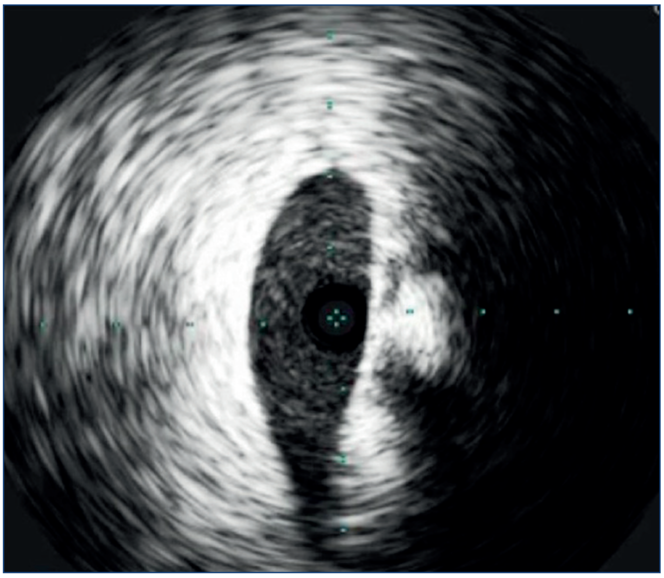

Figure 5. Normal vein wall.

When normal, the vein wall is very thin, virtual at ultrasound.

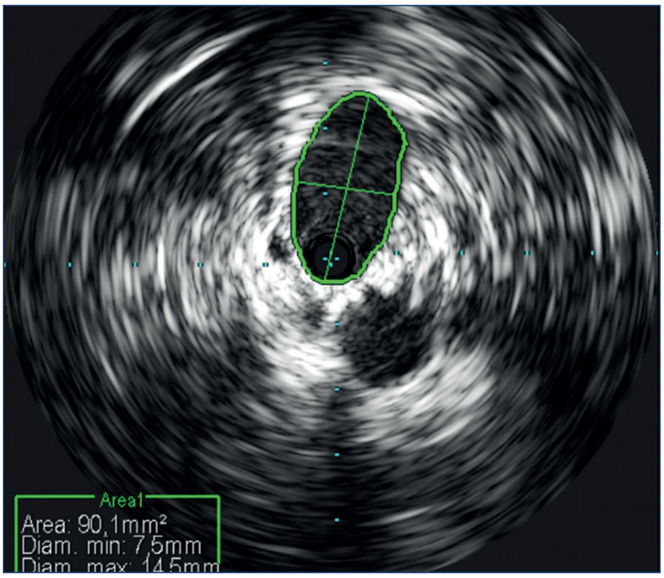

Figure 6. Transversal vein shape.

The transversal vein is not shaped like a cylindrical, but is usually oval and flattened.

variable *(Figure 7)* and IVUS helps identify lesions that are rarely detected by venography *(Figure 8)*, showing the different morphology of postthrombotic syndrome lesions *(Figure 9)*.

In primary obstruction, the vein stenosis is clearly visible even during a Valsalva maneuver. In cases of nonthrombotic iliac vein lesions, IVUS is able to measure quite precisely the stenosis and, consequently, given that the hemodynamic significance of a vein stenosis has been defined as a 50% reduction in the lumen, this diagnostic technique is able to confirm/exclude the pathology.[8]

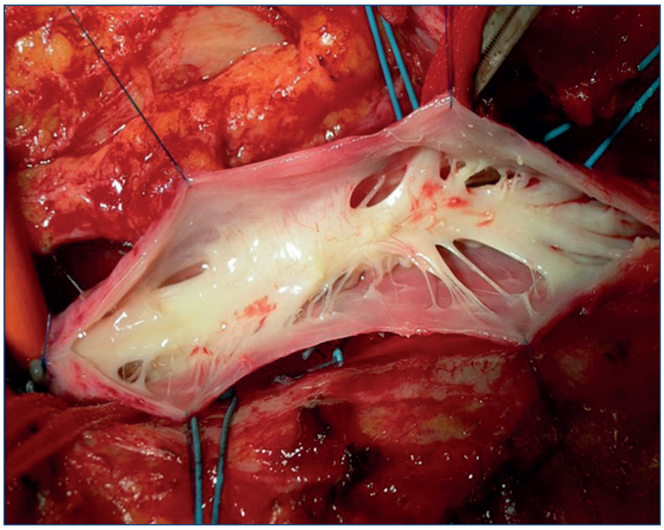

Figure 7. Intraoperative appearance of intraluminal postthrombotic fibrosis.

Septae and spurs occupy the vessel lumen determining stenosis.

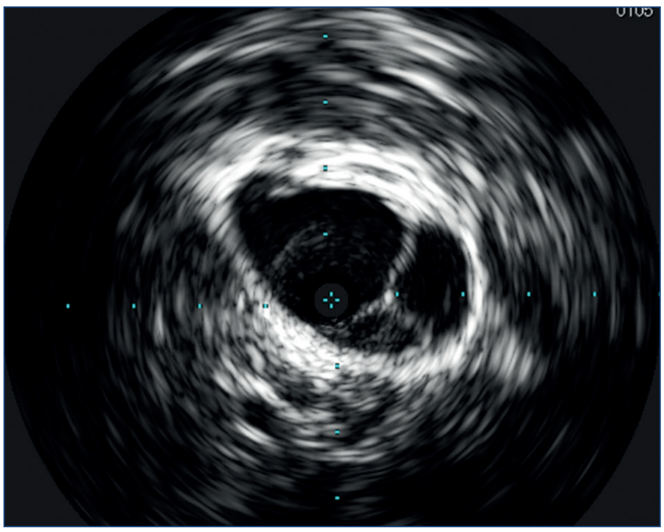

Figure 8. Intravascular ultrasound appearance of intraluminal postthrombotic septae in the iliac vein.

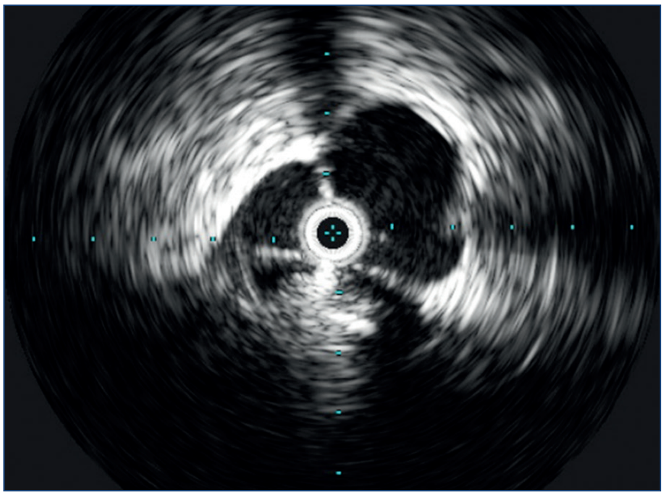

Figure 9. Complex postthrombotic lesion determining stenosis.

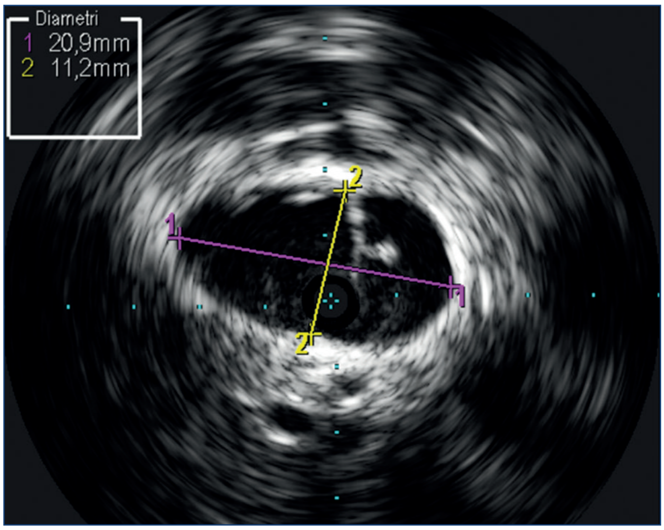

Figure 10. Vein diameters.

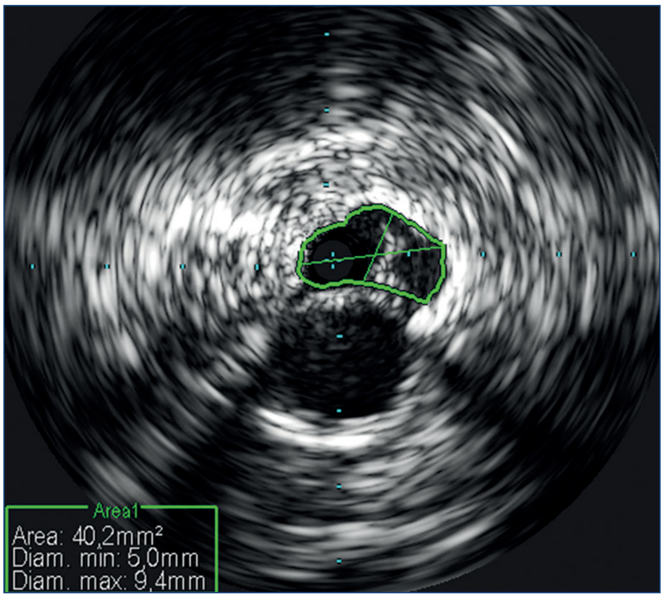

Figure 11. Transversal vein section area.

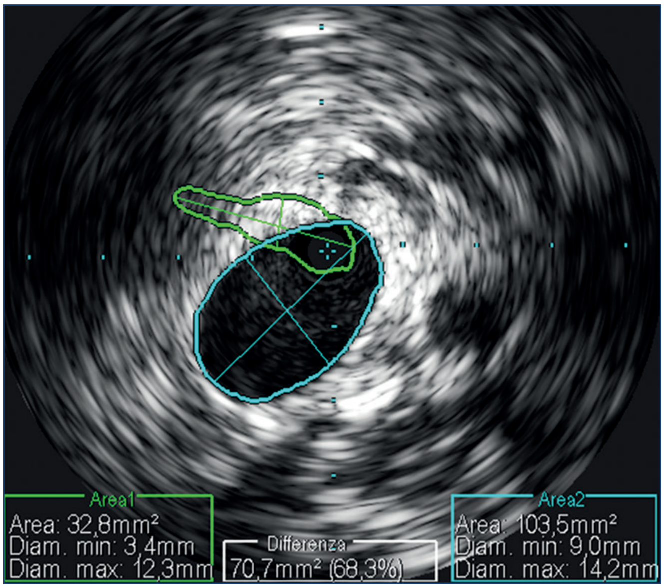

Figure 12. Calculation of the percentage of stenosis.

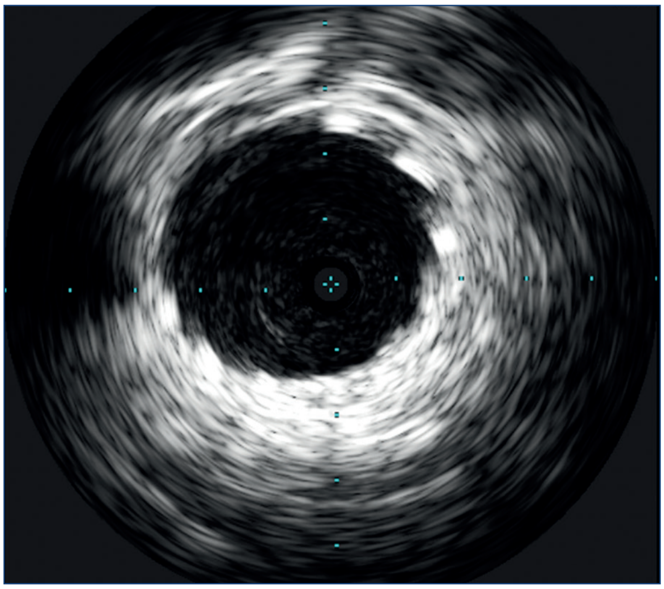

Figure 13. Stent control, showing correct deployment.

Considering the oval shape of the veins, diameter is not the best measurement to take *(Figure 10)* and it is better to rely on section area measurements *(Figure 11)*. Automatic calculation of the stenosis percentage can be performed automatically, comparing the lesion image with the reference vessel *(Figure 12)*. Once the lesion has been identified fully and ballooned, stent sizing can be adequately performed knowing the vein diameters and area. The final outcome can be assessed by IVUS, which helps determine if the stent is expanded correctly and if the lesions have been corrected completely *(Figure 13)*.

Conclusion

IVUS is a powerful diagnostic tool allowing for a better understanding of venous lesions when compared with other imaging techniques, such as venography, CT, and MRI. IVUS examinations provide a precise morphologic measurement of the vein stenosis and consequently ensure a correct stent sizing and deployment. Moreover, in a period of increased attention to radiation risk, this technique strongly reduces the amount of radiation and contrast dye injected. Despite the fact that the technique itself needs to be improved in terms of imaging quality, provided information, evidence of effectiveness, and costs, IVUS should be considered as an essential element during venous procedures.

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REFERENCES

1. Neglen P, Raju S. Balloon dilation and stenting of chronic iliac vein obstruction: technical aspects and early clinical outcome. *J Endovasc Ther.* 2000;7(2):79-91.
2. Neglen P, Thrasher TL, Raju S. Venous outflow obstruction: An underestimated contributor to chronic venous disease. *J Vasc Surg.* 2003;38:879-885.
3. Neglen P, Hollis KC, Olivier J, Raju S. Stenting of the venous outflow in chronic venous disease: long-term stent-related outcome, clinical, and hemodynamic result. *J Vasc Surg.* 2007;46:979-990.
4. Meissner MH, Eklof B, Smith PC, et al. Secondary chronic venous disorders. *J Vasc Surg.* 2007;46(suppl S):68S-83S.
5. Seager MJ, Busuttil A, Dharmarajah B, Davies AH. A systematic review of endovenous stenting in chronic venous disease secondary to iliac vein obstruction. *Eur J Vasc Endovasc Surg.* 2016;51:100-120.
6. Neglen P, Raju S. Intravascular ultrasound scan evaluation of the obstructed vein. *J Vasc Surg.* 2002;35:694-700.
7. Hingorani A, Alhabouni S, Ascher E, et al. Role of IVUS versus venograms in assessment of iliac-femoral vein stenosis. *J Vasc Surg.* 2010;52:804.
8. Gagne P, Tahara R, Fastabend C, et al. Venogram versus intra- vascular ultrasound for diagnosing and treating iliofemoral vein obstruction. *J Vasc Surg Venous Lymphat Disord.* 2017;5:678-687.
9. Jayaraj A, Buck W, Knight A, Johns B, Raju S. Impact of degree of stenosis in May-Thurner syndrome on iliac vein stenting. *J Vasc Surg Venous Lymphat Disord.* 2019;7(2):195-202.
10. Lugli M. IVUS. In: Guex J-J, Hamel-Desnos C , eds. *Ultrasons et Phlebologie. (in French).* Paris, France Editions Phlebologiques Françaises; 2016: 205-10.

Compression therapy is not mandatory after lower limb varices endovenous treatment

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Keywords:

compression compliance; compression therapy; sclerotherapy; thermal ablation

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Abstract

Compression therapy for varicose vein was widely admit by most vascular practitioners. Suddenly, in 2014, like a bolt from the blue, the Sox trial by Kahn et al[1] affirmed that elastic compression stockings did not prevent postthrombotic syndrome after a first proximal deep vein thrombosis, hence their findings do not support routine wearing of elastic compression stockings after deep vein thrombosis. Several reviewers tried to find bias in this study without evident success. Therefore, if in severe chronic venous insufficiency, compression is questioned, the interest of compression therapy after thermal ablation or sclerotherapy then becomes more a subject of debate. Due to the weakness of the studies, the American and British guidelines cannot give us recommendations on compression after treatment of varicose veins, but only suggestions without real conviction. Regardless of the studies with or without compression after sclerotherapy or thermal ablation, regardless of the duration or the dose of compression, there is no evidence that compression is mandatory and it could even be deleterious sometimes.

Introduction

The use of compression therapy stockings has always been affirmed and taught as a dogma. In medical schools, all teachers affirm it as natural evidence. In mathematics and philosophy, an axiom is an indemonstrable truth that must be admitted and a postulate is a statement that is assumed true without proof. Some think that many years or decades of experience are enough to reinforce their impression of having the truth. However, in medicine, a personal impression does not allow for giving guidelines. Only studies can guide therapeutic choices and the best ones are randomized controlled trials (RCT). On the one hand, compression stockings or medication cannot prevent the evolution of varicose veins. Palfreyman and Michaels[2] analyzed data from 11 prospective RCTs or systematic reviews, 12 nonrandomized studies, and 2 guidelines, concluding that, although compression improved symptoms, evidence is lacking to support compression garments to decrease progression or to prevent recurrence of varicose veins after treatment. On the other hand, compression stockings or venoactive drugs will find their use in the presence of venous symptomatology. Do we have to prescribe elastic bandages or compression stockings after thermal, chemical and combined ablation, and with which strength, class 2, class 3, or more? For how long, 2 days, 1 to 4 weeks, or more? There is no consensus as well evidence to reply to these questions.

Role of compression: hypotheses

What is the role of compression? Is it to improve treatment efficacy, reduce postoperative pain and bruising, reduce the risk of deep vein thrombosis and improve quality of life scores during convalescence?

Compression serves at least five purposes according to the hypotheses of Goldman et al[3]: (i) provide direct apposition of the treated vein walls to produce a more effective fibrosis; (ii) decrease the extent of thrombus formation that inevitably occurs with the use of all sclerosing solutions, thus decreasing the risk for recanalization of the treated vessel; (iii) decrease the extent of thrombus formation may also decrease the incidence of postsclerotherapy pigmentation; (iv) limiting thrombosis and phlebitic reactions may prevent the appearance of angiogenesis/telangiectatic matting; and (v) improve the function of the calf muscle pump because compression stockings will narrow the vein diameter, restoring competency to its valvular function, which decreases retrograde blood flow. External pressure will also retard the reflux of blood from incompetent perforating veins into the superficial veins. These assumptions are very theoretical and must be proven by RCT studies.

Compression after sclerotherapy

Compression after sclerotherapy for the great saphenous vein and the small saphenous vein

In an RCT by Hamel-Desnos et al in 2010,[4] which was performed at two centers, the outcome of foam sclerotherapy for the great saphenous vein and small saphenous vein with compression (15 to 20 mm Hg worn during the day for 3 weeks) or without compression was compared. The occlusion rate was 100% in both groups (assessments were done by independent experts). Side effects were few with no statistical difference between the two groups: no difference concerning deep vein thrombosis occurence, phlebitis, pigmentation, matting, pain, and quality of life (QOL). Patient satisfaction scores were high in both groups.

Partsch[5] commented about this study, saying that the compliance rate was mediocre, only 40% of patients wore compression stockings every day, but the results without compression are so good that it would have been very difficult to obtain a superior outcome even by using stronger and more consistent compression. However, if just 40% of the patients wore compression stockings every day this does not mean that 60% of the patients did not wear compression at all, but rather less than 7 days a week, which corresponds to the data found in other studies.

Compression after sclerotherapy for telangiectasias and reticular leg veins

In another RCT (single-center) by Kern et al,[6] patients were randomized to wear medical compression stockings (23 to 32 mm Hg) daily for 3 weeks or no compression after treatment of telangiectasias and reticular veins on the lateral aspect of the thigh in a single session of standardized liquid sclerotherapy (chromated glycerin). Outcomes were assessed by a patient satisfaction analysis and a quantitative evaluation of photographs taken from the lateral aspect of the thigh before and again at 52 days (on average) after sclerotherapy by two blinded expert reviewers. The rate of pigmentation and matting was low and did not differ significantly between the two groups. Independent experts found better results according to the photos by improving clinical vessel disappearance for the compression group, but patient satisfaction was similar in both groups. What is best, the opinion of experts or patients?

According to Partsch,[5] based on experience, he said, I would still recommend applying good compression especially after injection into the superficial side-branches in order to prevent phlebitis and hyperpigmentation. However, as we will see later, no compression stockings can narrow and, even less, completely compress the superficial vein, especially in the thigh while standing.

Compression after thermal ablation

To date, 5 RCTs and a meta-analysis have been published. In 2013, Bakker et al[7] compared compression stockings after endovenous laser ablation (EVLA) of the great saphenous vein for 48 hours vs 7 days (n=69 patients). After 1 week, the pain score as evaluated with the visual analog scale (VAS) was 3.7±2.1 vs 2.0±1.1. He concluded that compression stockings for longer than 2 days reduced pain and improved physical function during the first week after treatment.

In 2014, Elderman et al[8] randomized 111 patients to either 24 hours of bandages or 24 hours of bandages plus 2 weeks of elastic compression stockings following EVLA. He concluded that there was small significant reduction in postoperative pain and the use of analgesics compared with not wearing compression stockings. In an RCT published in 2016, Krasznai et al[9] compared 4 hours of leg compression with 72 hours of leg compression following radiofrequency ablation (RFA). They found no difference in leg edema pain, postoperative pain, and time to full recovery. He concluded that a shorter duration of compression had fewer complications (eg, blistering, skin irritation).

In 2016, Ye K et al[10] randomized 400 patient to either elastic compression stockings or no compression after EVLA. In the first week, patients in the elastic compression stocking group experienced less pain according to the VAS score (2.3±1.4 vs 3.3±1.6) and edema. He concluded that elastic compression stockings provided no benefit in QOL and mean time to return to work, but reduced the severity of pain and edema during the first week. In 2017, Ayo D et al[11] randomized 70 patients after RFA (91%) and EVLA (9%) to either thigh-high compression stocking (30 to 40 mm Hg) for 7 days or no compression. No significant differences in pain scores at day 7 (mean, 2.11 vs 2.81), CIVIQ-2 scores at 1 week (mean, 36.9 vs 35.1), and bruising score (mean, 1.2 vs 1.4) were observed. He concluded that compression might be an unnecessary adjunct following great saphenous vein ablation.

In 2018, Al Shakarchi J et al[12] published a systematic review and meta-analysis statement on the role of compression after endovenous ablation of varicose veins. The primary outcomes for this study were the pain score and complications. The secondary outcomes were time to full recovery, quality of life score, leg circumference, bruising score, and compliance rates. Five studies (the five studies discussed above) were analyzed, which included 734 patients in total. Short-duration compression therapy ranged from 4 hours to 2 days and the longer duration ranged from 3 to 15 days. He found that a single study showed a better outcome in terms of complications with short-duration compression therapy; a single study showed a better outcome in terms of complications with a short duration of compression therapy; a single study showed benefit on pain and QOL with extended compression therapy, whereas the others did not. There was no significant difference in terms of bruising, recovery time, and leg swelling *(Table I)*. He concluded that there is no evidence for the extended use of compression after endovenous ablation of varicose veins.

In my daily practice, I routinely prescribe class 2 compression stockings after thermal ablation. I put the compression stockings on myself and they are to be kept on day and night for 4 days and then only during the day, but I provide a very precise recommendation to remove the stockings if they are painful or uncomfortable and to take a shower.

Study	Pain	Bruising	QOL	Recovery time	Complications
Bakker et al[7]	Significant difference in favor of extended therapy	NS	Significant difference in favor of extended therapy	NS	No significant difference
Elderman et al[8]	No significant difference	NS	No significant difference	No significant difference	No significant difference
Krasznai et al[9]	No significant difference	NS	NS	No significant difference	Significant difference in favor of shorter therapy (skin irritation, blisters)
Ye et al[10]	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference
Ayo et al[11]	No significant difference	No significant difference	No significant difference	NS	No significant difference

Table I. The effect of compression therapy after endovenous ablation of varicose veins.

Abbreviations: NS, not specified; QOL, quality of life

Modified from reference 12. Al Shakarchi J et al. J Vasc Surg Venous Lymphat Disord. 2018;6(4):546-550.

Duration of compression

Regularly, the optimal duration of compression has come into question. Should they be worn for 2 days, 1 to 4 weeks, or more? In 2007, Biswas et al[13] published a prospective study that randomized patients to either 1 week or 3 weeks of compression after high ligation and stripping of the saphenous vein. They found no benefit of wearing compression stockings for more than 1 week with respect to postoperative pain, number of complications, time to return to work, or patient satisfaction for up to 12 weeks following surgery.

The UK recommendations (NICE),[14] based on two studies,[4,15] suggest not offering compression bandaging or hosiery for more than 7 days after completion of interventional treatment of varicose veins.

In 2009, Houtermans-Auckel et al[15] reported their study in which patients were randomized to 4 weeks of compression stockings or no compression after ligation and stripping of the great saphenous vein. There were no between-group differences in leg edema, pain, or other complications (bleeding, infection, seroma, and paresthesia). However, there was a statistically significant difference in the number of days of sick leave in favor of the no compression group (11 days vs 15 days). The reason could be that patients would still feel sick with compression stockings, which is why the UK guidelines[14] recommend that patients can be advised that, in most cases, they are able to return to work while wearing compression bandaging or hosiery.

In 2016, El-Sheikha et al[16] sent a postal questionnaire to 348 consultant members of the Vascular Society of Great Britain and Ireland. Among those who responded (41% surgeons, representing at least 61% of the vascular units), all surgeons prescribed compression. Following ultrasound-guided foam sclerotherapy, the median time was 7 days (range 2 days to 3 months) and, after endothermal ablation, 10 days (range 2 days to 6 weeks). Different combinations of bandages, pads, and compression stockings were reported. They concluded that compression regimes after treatments for varicose veins vary significantly and more evidence is needed to guide practice.

The 2019 US guidelines[17] say that, in the absence of convincing evidence, we should recommend using our best clinical judgment to determine the duration of compression therapy after sclerotherapy or thermal ablation with no gradation.

Dose of compression

In 2005, Partsch and Partsch[18] investigated the external pressure necessary to narrow and occlude leg veins in different body positions. Initial narrowing occurs with a median pressure between 30 and 40 mm Hg in the sitting and standing positions on the leg. Complete occlusion of superficial and deep leg veins occurs with 20 to 25 mm Hg in the supine position, between 50 and 60 mm Hg in the sitting position, and at about 70 mm Hg in the standing position.

In the supine position, Uhl and Lun[19] compared the great saphenous vein using a CT scan in patients wearing no compression, class II stockings (18 mm Hg ankle), class III stockings (26 mm Hg ankle) or class IV stockings (45 mm Hg ankle). Regardless of compression, there was no effect on the great saphenous vein. Compression cannot narrow the great saphenous vein on the thigh *(Figure1)*.

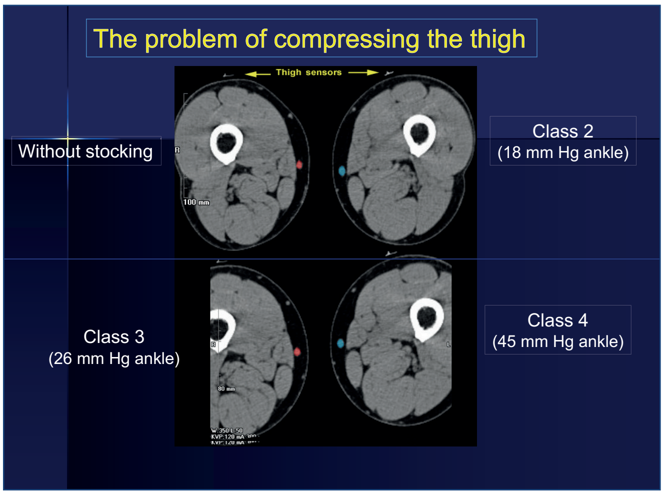

Figure 1. Stockings at the thigh are useless: regardless of the compression, there is no effect on the great saphenous vein on the thigh.

Modified from reference 19. Uhl JF, Lun B. Proc Int. Sympo CNVD. 2004;3:135-138.

It is quite easy to check this information by echography. Personally, I have measured the great saphenous vein on the middle part of the thigh and on the upper part of the leg, the patients in a standing position wearing class III stockings (30 mm Hg) or nothing. As shown in the images *(Figures 2 and 3)*, measurements are equivalent with elastic stockings (through the stocking) or without (directly on the skin).

Shouler et al[20] concluded that 15 mm Hg of compression was as effective as 40 mm Hg in terms of minimizing bruising and thrombophlebitis after saphenous stripping, but low

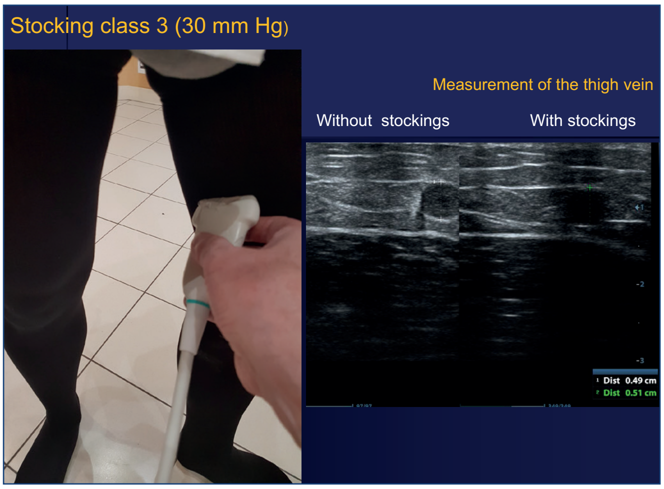

Figure 2. Compression stocking (30 mm Hg): measurements by echography on the thigh are equivalent without and with stockings.

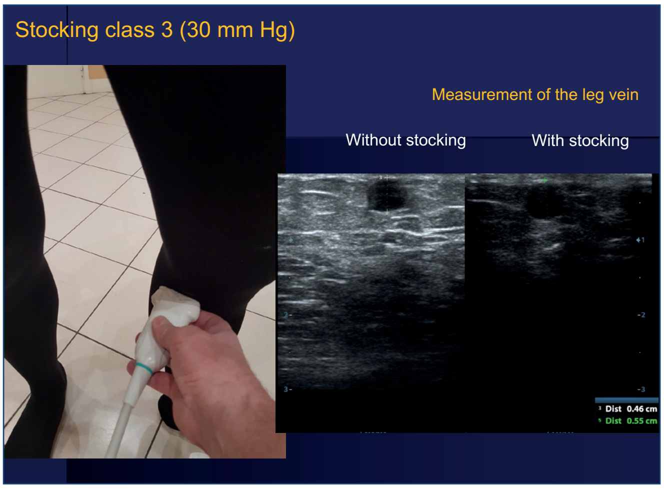

Figure 3. Compression stocking (30 mm Hg): measurements by echography on the leg are equivalent without and with stockings.

compression stockings proved to be more comfortable. After sclerotherapy, bandaging is not required if a high-compression stocking is used. Conversely, Cavezzi et al[21] concluded that compression with 23 and 35 mm Hg medical compression stockings after catheter foam sclerotherapy plus phlebectomy was effective and well tolerated during the immediate- and short-term. Nevertheless, compression with 35 mm Hg medical compression stockings provided fewer adverse postoperative symptoms and a slightly better improvement in edema.

In France, the maximum pressure of a compression stocking is about 45 mm Hg, unless the patient wears a double stocking, which is unbearable and quite impossible to put on. Thus, the theory that direct apposition of the treated vein walls produce a more effective fibrosis and decrease the extent of thrombus formation is completely erroneous.

Compliance

Compliance with compression therapy in chronic venous disease is still a subject of debate as most patients are not using compression therapy as prescribed; therefore, how can compliance be improved. In 2007, Raju published[22,23] a study to assess the compliance of 3144 new chronic venous disease patients seen from 1998 to 2006. Only 21% of patients reported using the stockings on a daily basis, 12% used them on most days, and 4% used them less often. The remaining 63% did not use the stockings at all or abandoned them after a trial period.

In 2017, Soya et al[24] assessed compliance in a Sub-Saharan population (Ivory Coast). The majority of patients (75%) agreed to wear their stockings after prescription with a good compliance rate of 58.5% at the beginning of the prescription. During the study, they found that 11% wore the compression stockings with an optimal duration of compliance of 6 months. Over 12 months, this rate fell to 7.5%. In 2018, Ayala et al[25] also assessed the compliance in a tropical country (Colombia), where 31.8% of the patients reported wearing compression stockings as prescribed, 31.4% reported wearing compression stockings on most days, 28.3% reported wearing compression stockings intermittently, and 8.5% reported not wearing compression stockings at all.

Uhl et al[26] published a study where the real compliance to compression therapy was objectively measured with a thermal probe inserted in the stocking that recorded the skin temperature every 20 minutes for 4 weeks. Therefore, the wearing of stockings was accurately recorded, which permitted the actual number of hours per day and days per week during which the compression was worn to be estimated. The average daily wearing time was only 5.6 hours and the average number of days worn per week was only 3.4 days. When patients have extensive and weekly recommendations, just during 4 weeks, the average daily wearing time was increased to 8 hours and the average number of days worn per week was 4.8 days. Even with repeated and clear recommendations, compliance improved, but, on average, compression was not worn the entire day and not every day, which is the real objective. In all other studies, the compliance rate was subjective and relied on the allegations of patients who sometimes do not want to disappoint the practitioner and gives information that does not exactly correspond to reality.

Compliance with wearing elastic compression stockings is mediocre. Most patients are not using compression therapy as prescribed. Heat in hot countries or during the hot season aggravates this poor compliance. Furthermore, over the long term, compliance gets worse. The main factors for noncompliance are discomfort, threading difficulties, skin problems (itching), unattractive, unfavorable working environment, and patient neglect. Another factor for the poor compliance is the cost of the stockings, which must be regularly renewed, ideally at least every 6 months.

Paresthesia

In the study by Brittenden et al,[27] they found that, after foam sclerotherapy, the rate of numbness at 6 weeks on average was 5.7% and at 6 months 4.0% *(Table II)*. After traditional surgery, the paresthesia rate was usual around 15%. After laser ablation, paresthesia may occur, but at a much lower rate. Conversely, the main benefit of sclerotherapy is the absence of paresthesia. As you do not heat the vein wall, it is quite impossible to damage the nerve. Surprisingly, in this article, there are no comments about why numbness happens after sclerotherapy. When it occurs, it is probably due to excessive compression by bandages. The use of compression stockings after sclerotherapy, which is often recommended, has not yet been proven useful, but can sometimes be potentially deleterious. Probably much more with bandages than with stockings, especially on the lateral aspect at the upper part of the leg, where the fibular nerve is very superficial *(Figure 4)* and it could be damaged by excessive compression.

Guidelines

The 2011 US guidelines[28] suggest using compression therapy for patients with symptomatic varicose veins (grade 2C), but recommend against compression therapy as the primary treatment if the patient is a candidate for saphenous vein ablation (grade 1B)

The 2019 US guidelines[17] recommend the following:
After surgical or thermal procedures for varicose veins: (i) guideline 1.1: when possible, use compression (elastic stockings or wraps) (grade 2 C); (ii) guideline 1.2: if compression dressings are to be used post-procedurally, those providing pressures >20 mm Hg together with eccentric pads placed directly over the vein ablated or operated on provide the greatest reduction in postoperative pain (grade 2B); (iii) guideline 2.1: in the absence of convincing evidence, we recommend best clinical judgment to determine the duration of compression therapy after thermal ablation or stripping of the saphenous veins treatment

Event	Laser group (n=210)	Foam group (n=286)	Surgery group (n=289)
Numbness at 6 weeks	22/193 (11.4%)	15/265 (5.7%)	45/251 (17.9%)
Numbness at 6 months	17/183 (9.2%)	10/251 (4.0%)	37/236 (15.6%)
Skin staining at 6 weeks	18/193 (9.3%)	105/265 (39.6%)	20/251 (8.0%)
Skin staining at 6 months	32/183 (17.4%)	92/251 (36.6%)	24/236 (10.2%)

Table II. Numbness after foam sclerotherapy: 5.7% at 6 weeks and 4.0% at 6 months.
Modified from reference 27. Brittenden J et al. N Engl J Med. 2014;371(13):1218-1227. © 2014, Massachusetts Medical Society.

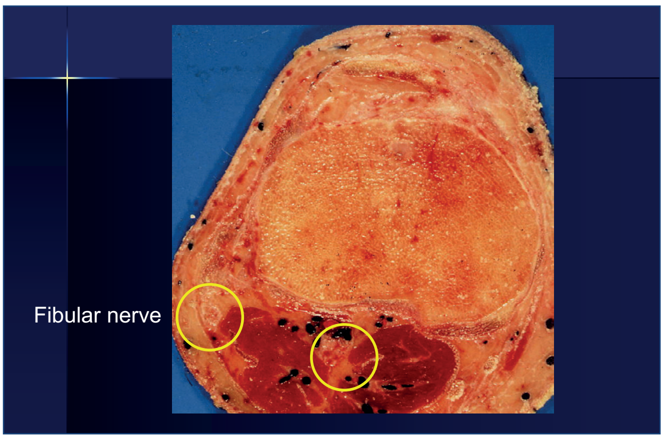

Figure 4. The fibular nerve is very superficial at the upper part and lateral aspect of the leg, which means that compression could be deleterious. Image courtesy of Professor Gillot.

After sclerotherapy for varicose veins: (i) guideline 3.1: use compression therapy immediately after treatment of superficial veins to improve the outcomes of sclerotherapy (grade 2C); (ii) guideline 3.2: in the absence of convincing evidence, it is recommended to use the best clinical judgment to determine the duration of compression therapy after sclerotherapy.

The 2013 UK recommendations (NICE)[14] say that, as there is no convincing evidence for using or not using compression therapy, the Guideline Development Group felt that they could not make a recommendation.

Due to the small number, the weakness of the studies, and the lack of real evidence, the American and British recommendations cannot give us recommendations on compression after treatment of the varicose veins, but only suggestions without real conviction. So must we prove that compression is not mandatory or prove that compression is necessary?

Conclusion

Compression therapy in the treatment of leg ulcers is the main factor of success and cannot be called into question. All the guidelines recommend compression therapy to aid healing of venous ulceration. For patients with deep venous reflux, compression therapy is needed in the long term. For patients with chronic venous insufficiency, compression may not be necessary, but, depending on the symptomatology and in any case, it must be prescribed in a reasonable way and never as an obligation that cannot be discussed. To have the best compliance, especially for the long term, you have to advise the patients of the benefits of this treatment and repeat the recommendations regularly. Only on this condition can you expect the patient to adhere to the treatment. After thermal or chemical ablation, as there is no convincing evidence for using or not using compression therapy, you should let people feel free to assess whether they are benefiting from it or not.

To improve compliance, the hosiery must be prescribed carefully (not too strong or too light) and be measured properly in an orthopedic shop will ensure that you get a garment (knee highs, stockings, or pantyhose) that fits properly, which will be worn and not left in a drawer. Regarding stocking manufacturers, compression is not mandatory, but it does not mean no compression at all, but a prescription is often necessary, depending on the symptomatology and in agreement with the patient.

To the question, doctor should I wear compression stockings? You can answer, no it is not mandatory. After this question, you can ask your patients if they feel better when wearing the stockings? If the answer is yes, then put them on, and, if it is no, take them off! Compression must be a comfort and not a constraint. Why compel your patient to use compression therapy that he will stop because he cannot feel any advantage or that the stress is more important than the benefit? Why let your patients feeling guilty about the bad results of your treatment because they have not worn their compression therapy?

It is better to explain to your patients the benefits of compression and leave them free to wear according to the well-being felt.

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REFERENCES

1. Kahn SR, Shapiro S, Wells PS, et al; SOX Trial Investigators. Compression stockings to prevent post-thrombotic syndrome: a randomised placebo-controlled trial. *Lancet.* 2014;383(9920):880-888.
2. Palfreyman SJ, Michaels JA. A systematic review of compression hosiery for uncomplicated varicose veins. *Phlebology.* 2009;24(suppl 1):13-33.
3. Goldman MP, Bergan JJ, Guex JJ, eds. *Sclerotherapy: Treatment of Varicose and Telangectatic Leg Veins.* 4th edition. New York, NY: Mosby Elsevier; 2006:148-149.
4. Hamel-Desnos CM, Guias BJ, Desnos PR, Mesgard A. Foam sclerotherapy of the saphenous veins: randomised controlled trial with or without compression. *Eur J Vasc Endovasc Surg.* 2010;39(4):500-507.
5. Partsch H. www.venousdigest.com 2010;17(3).
6. Kern P, Ramelet AA, Wütschert R, Hayoz D. Compression after sclerotherapy for telangiectasias and reticular leg veins: a randomized controlled study. *J Vasc Surg.* 2007;45(6):1212-1216.
7. Bakker NA, Schieven LW, Bruins RM, van den Berg M, Hissink RJ. Compression stockings after endovenous laser ablation of the great saphenous vein: a prospective randomized controlled trial. *Eur J Vasc Endovasc Surg.* 2013;46(5):588-592
8. Elderman JH, Krasznai AG, Voogd AC, Hulsewé KW, Sikkink CJ. Role of compression stockings after endovenous laser therapy for primary varicosity. *J Vasc Surg Venous Lymphat Disord.* 2014;2(3):289-296.
9. Krasznai AG, Sigterman TA, Troquay S, et al. A randomised controlled trial comparing compression therapy after radiofrequency ablation for primary great saphenous vein incompetence. *Phlebology.* 2016;31(2):118-124.
10. Ye K, Wang R, Qin J, et al. Post-operative benefit of compression therapy after endovenous laser ablation for uncomplicated varicose veins: a randomised clinical trial. *Eur J Vasc Endovasc Surg.* 2016;52(6):847-853.
11. Ayo D, Blumberg SN, Rockman CR, et al. Compression versus no compression after endovenous ablation of the great saphenous vein: a randomized controlled trial. *Ann Vasc Surg.* 2017;38:72-77.

REFERENCES

12. Al Shakarchi J, Wall M, Newman J, et al. The role of compression after endovenous ablation of varicose veins. *J Vasc Surg Venous Lymphat Disord*. 2018;6(4):546-550.

13. Biswas S, Clark A, Shields DA. Randomised clinical trial of the duration of compression therapy after varicose vein surgery. *Eur J Vasc Endovasc Surg*. 2007;33:631-637.

14. National Institute for Health and Care Excellence. Varicose veins: diagnosis and management. http://guidance.nice.org.uk/cg168. Published July 24, 2013. Accessed July 19, 2017.

15. Houtermans-Auckel JP, van Rossum E, Teijink JA, et al. To wear or not to wear compression stockings after varicose vein stripping: a randomised controlled trial. *Eur J Vasc Endovasc Surg*. 2009;38(3):387-391.

16. El-Sheikha J, Nandhra S, Carradice D, et al. Compression regimes after endovenous ablation for superficial venous insufficiency. *Phlebology*. 2016;31(1):16-22.

17. Lurie F, Lal BK, Antignani PL, et al. Compression therapy after invasive treatment of superficial veins of the lower extremities. *J Vasc Surg Venous Lymphat Disord*. 2019;7(1):17-28.

18. Partsch B, Partsch H. Calf compression pressure required to achieve venous closure from supine to standing positions. *J Vasc Surg*. 2005;42:734-738.

19. Uhl JF, Lun B. Proceedings of the IIth International Symposium on computer-aided noninvasive vascular diagnostics. 2004;3:135-138.

20. Shouler PJ, Runchman PC. Varicose veins: optimum compression after surgery and sclerotherapy. *Ann R Coll Surg Engl*. 1989;71:402-404.

21. Cavezzi A, Mosti G, Colucci R, Quinzi V, Bastiani L, Urso SU. Compression with 23 mmHg or 35 mmHg stockings after saphenous catheter foam sclerotherapy and phlebectomy of varicose veins: a randomized controlled study. *Phlebology*. 2019;34(2):98-106.

22. Raju S1, Hollis K, Neglen P Use of compression stockings in chronic venous disease: patient compliance and efficacy. *Ann Vasc Surg*. 2007;21(6):790-795.

23. Raju S. Compliance with compression stockings in chronic venous disease. *Phlebolymphology*. 2008;15(3):103-106.

24. Soya E, N'djessan JJ, Koffi J, Monney E, Tano E, Konin C. Factors of compliance with the wearing of elastic compression stockings in a Sub-Saharan population [article in French]. *J Med Vasc*. 2017;42(4):221-228.

25. Ayala Á, Guerra JD, Ulloa JH, Kabnick L. Compliance with compression therapy in primary chronic venous disease: Results from a tropical country. *Phlebology*. 2018 Sep 6. Epub ahead of print.

26. Uhl JF, Benigni JP, Chahim M, Fréderic D. Prospective randomized controlled study of patient compliance in using a compression stocking: importance of recommendations of the practitioner as a factor for better compliance. *Phlebology*. 2018;33(1):36-43.

27. Brittenden J, Cotton SC, Elders A, et al. A randomized trial comparing treatments for varicose veins. *N Engl J Med*. 2014;371(13):1218-1227.

28. Gloviczki P, Comerota AJ, Dalsing MC, et al. The care of patients with varicose veins and associated chronic venous diseases. *J Vasc Surg*. 2011;53(suppl 5):2S-48S.