ISSN (electrónico): 1695-2987 - ISSN (papel): 0003-3170

Angiología

Special Article

Guidelines on lower limb venous system vascular assessment from SEACV vascular diagnosis chapter

Guía de la exploración venosa de los miembros inferiores del capítulo de diagnóstico vascular de la SEACV

Xavier Martí Mestre[1], Alejandro Rodríguez Morata[2], Rodrigo Rial Horcajo[3], Aitziber Salazar Agorria[4], Antonio Romera Villegas[1], Ramón Vila Coll[1]

[1]Angiology, Vascular and Endovascular Surgery Department. Hospital Universitari de Bellvitge. L'Hospitalet de Llobregat, Barcelona. Spain. [2]Angiology, Vascular and Endovascular Surgery Department. Hospital Quirón Salud. Málaga, Spain. [3]Angiology, Vascular and Endovascular Surgery Department. Hospital Universitario HM Torrelodones. Torrelodones, Madrid. Spain. [4]Angiology, Vascular and Endovascular Surgery Department. Hospital de Basurto. Bilbao, Spain

Abstract

Clinical practice guidelines have positioned themselves as an extremely useful, accessible, and necessary tool to properly carry out daily work. The Capítulo de Diagnóstico Vascular of Sociedad Española de Angiología y Cirugía Vascular has been developing this instrument of dissemination, consolidation and homogenization of knowledge in the aspect of vascular diagnosis, which is the one that concerns it. Venous insufficiency of the lower limbs is one of the richest and most defended fields of study and diagnosis since the Chapter on Vascular Diagnosis. This entity has already published two excellent guides on this subject. Although at a lower rate and with a different philosophy than other kind of clinical guidelines, diagnostic guidelines must also be updated, incorporating new areas of knowledge, changing points of view, or simply, explaining the same facts from other perspectives.

With this spirit we present this new update of the "Guide to the venous exploration of the lower limbs", being very clear that we are not trying, far from it, to replace those already published, but to complement them and add knowledge. From this perspective, we have captured the ultrasound findings that we can record in a venous study; we have included a chapter on the "normal" ultrasound anatomy of the veins of the lower extremities, updating its gazetteer; we have detailed in great detail what would be a venous ultrasound examination of the lower limbs; we have reserved a space to remember and update ultrasound study protocols of venous thrombosis; and, finally, and as a star theme, we have developed an innovative chapter on the study of pelvic venous insufficiency.

Keywords:
Doppler ultrasound. Venous insufficiency of lower extremities. Pelvic venous insufficiency.

Received: 13/06/2022 • Accepted: 01/09/2022

Conflict of interest: the authors declare no conflict of interest.

Martí Mestre X, Rodríguez Morata A, Rial Horcajo R, Salazar Agorria A, Romera Villegas A, Vila Coll R. Guidelines on lower limb venous system vascular assessment from SEACV vascular diagnosis chapter. Angiología 2023;75(1):25-42

DOI: http://dx.doi.org/10.20960/angiologia.00440

Correspondence:

Xavier Martí Mestre. Angiology, Vascular and Endovascular Surgery Department. Hospital Universitari de Bellvitge. Carrer de la Residència, 14-20. 08907 L'Hospitalet de Llobregat, Barcelona. Spain
e-mail: xamame@hotmail.com

Resumen

Las guías de práctica clínica se han posicionado como una herramienta extremadamente útil, accesible y necesaria para llevar a cabo de forma adecuada el trabajo diario. El Capítulo de Diagnóstico Vascular de la Sociedad Española de Angiología y Cirugía Vascular viene desarrollando este instrumento de difusión, consolidación y homogenización del saber en la vertiente del diagnóstico vascular, que es la que le incumbe. La insuficiencia venosa de las extremidades inferiores es uno de los campos de estudio y diagnóstico clásicos más ricos y defendidos desde el Capítulo de Diagnóstico Vascular. Esta entidad ya ha publicado dos excelentes guías sobre este tema. Aunque a un ritmo menor y con una filosofía diferente a otro tipo de guías clínicas, las guías de diagnóstico también deben actualizarse para incorporar nuevas áreas de saber, cambiar puntos de vista o, simplemente, explicar los mismos hechos desde otras perspectivas.

Con este ánimo presentamos esta nueva actualización de la *Guía de la exploración venosa de los miembros inferiores,* teniendo muy claro que no tratamos, ni mucho menos, de sustituir las ya publicadas, sino de complementarlas y sumarles conocimientos. Desde esta perspectiva, hemos plasmado los hallazgos ecográficos que podemos constar en un estudio venoso, hemos incluido un capítulo sobre la anatomía ecográfica "normal" de las venas de las extremidades inferiores, actualizando su nomenclátor, hemos pormenorizado con todo lujo de detalles lo que sería una exploración ecográfica venosa de miembros inferiores, hemos reservado un espacio para recordar y actualizar protocolos de estudio ecográfico de la trombosis venosa y, finalmente, y como tema estrella, hemos desarrollado todo un capítulo innovador sobre el estudio de la insuficiencia venosa pélvica.

Palabras clave: Ecografía Doppler. Insuficiencia venosa de extremidades inferiores. Insuficiencia venosa pélvica.

INTRODUCTION

Ultrasonographic assessment of lower limb venous diseases is one of the most classical and categorized studies in Doppler ultrasound technology applied to vascular disease. The Vascular Diagnosis chapter has led to the publication of two excellent guidelines on this matter (1-3). The last update dates back 7 years ago. The philosophy behind the drafting of these medical guidelines includes the periodic review of them. There are certain novelties in lower limb venous assessment we believe that should be discussed here. We should mention that the very nature of the guidelines oriented towards diagnosis prevents the modification of their contents the same way it would happen with other guidelines on different matters of discussion. Therefore, most contents from previous guidelines are still effective, and these are totally accepted by the reviewers of the current version.

Lower limb venous assessment should be performed while trying to give a different view and all possible novelties on this topic from a pedagogical approach to it. Like we said, previous guidelines beautifully expose different aspects that we think we don't need to go over in this update. Other aspects will be reviewed with a new different approach.

FINDINGS OF LOWER EXTREMITIES ON VENOUS DOPPLER ULTRASOUND

Venous ultrasonographic assessment of lower limbs is one of the most classical ones we can perform because ultrasound is harmless, on the one hand, and because of the huge amount of information this easy assessment can provide us with, on the other. Venous Doppler ultrasound of lower limbs gives information on venous morphology, the number and position occupied by venous vessels, vascular structure, and the most important thing of all, real-time information on blood flow hemodynamics inside the veins (4,5).

Morphological alterations

Morphological alterations detected and assessed by the ultrasound include venous vessel tortuosities, venous dilatations and narrowing or increased collaterality. Venous tortuosities often reveal the presence of varicose veins on the ultrasound. Lower limb superficial vein dilatation equally translates, and even sizes, the varicose phenomenon or even replacement phenomena in deep venous thromboses. Circumscribed dilatation of deep venous system performed more than double the diameter of the consecutive segment is suggestive of venous aneurysm. The presence of a deep vein system with stenosed lumen can be indicative of the presence of partially resolved thrombotic events. Increased collaterals can appear again in the superficial venous system varicose pathology. Also, there can be a replacement reaction to proximal thrombotic phenomena in deep vein system.

Alterations in name and position

Alterations in the number and position seen on the lower limb ultrasound assessment include venous duplicities, and the association of veins with their homonymous arteries and adjacent musculature. Duplicity of lower limb venous structures is a relatively common phenomenon. The presence of anomalous associations between veins from the deep vein system and their homonymous arteries, and position alterations of vascular pack with respect to musculature with which it is associated are rarer and much more complex, although possible, to assess on the ultrasound.

Structural alterations

Structural venous alterations can manifest through two different ways. On the one hand, the total or partial venous lumen occupation by material of certain ultrasound characteristics can be confirmed. This ultrasound image informs us of the presence of IV material that is typical though not exclusive to thrombotic phenomena. It is even possible to analyze the ultrasound characteristics of the material found and establish a certain evolutionary timeline of a venous thrombus. On the other hand, the ultrasound provides morphological assessments of the thickening of vascular wall is, which is suggestive of partially resolved previous thrombotic phenomena.

Hemodynamic alterations

Finally, Doppler ultrasound offers the unique possibility of assessing the hemodynamic alterations of blood vessels. In the first place, hemodynamic assessments reveal, at lower limb venous level, the presence of absence of flow inside the venous vessels. Also, hemodynamic assessments accurately examine the characteristics of this flow and, above all, its direction inside the veins. The lack of flow in a segment during venous assessment warns us on the possible occlusion of this sector. On the other hand, flow characterization regarding respiratory modulation or the presence of increased flow waves with certain maneuvers can be indicative of occlusive phenomena proximal or distal to sector under assessment. Finally, establishing venous flow directionality is the main hemodynamic argument when talking about venous reflux, and introducing the idea of venous insufficiency in our assessment.

DOPPLER ULTRASOUND ASSESSMENT OF HEALTHY VEINS

At this point, we believe we should think of what a vein without lower extremity venous disease really looks like. For the proper assessment of a vascular structure, it should be studied through the 3 classic modes of Doppler ultrasound, that is, B-mode or gray scale imaging, color flow Doppler, and pulsed wave Doppler.

Veins in gray scale imaging or B-mode ultrasound and in cross-sectional views of the target extremity acquire a round-shaped morphology that is almost circular. Venous lumen shows a lack of homogeneous echogenicity, that is, it's completely black. This lumen is surrounded by a thin hyperechogenic annulus —white or gray— that happens to be the vascular wall. On the real time imaging, this structure lacks the typical pulsatility of an arterial wall. However, it has the property of compressibility to the transducers pressure.

The application of color flow Doppler to venous assessment totally and homogeneously fills up the venous lumen with color. Also, the interphase between the color of venous lumen and the hyperechogenic annulus reveals the endothelium of the target vein.

Color flow Doppler mode but especially pulsed wave Doppler provide information on blood flow inside the venous vessel. Venous flow in lower extremities is characterized by a unidirectional flow wave across the entire cycle with low or very low velocities, and barely any variability in the different stages of the cycle. This scarce variability is conditioned by respiratory stages rather than arterial pulsatility.

The phenomenon through which venous flow confirmed on the Doppler ultrasound shows this variability associated with respiration is called respiratory modulation or phasicity. It seems logical somehow that flow wave inside a non-pathological wave should remain directionality towards the heart and, by convection, cardiopetal venous flow appears on the pulsed wave Doppler chart underneath the baseline. Musculature contraction, whether active or passive, distal to the venous site of the ultrasound assessment manifests in the latter, in the absence of pathology, by an increased flow wave while always keeping flow above baseline levels during and after contraction. This increased flow with muscular contraction distal to insonation is called positive A-wave (6,7).

ANATOMY ULTRASOUND OF LOWER LIMB VENOUS ASSESSMENT

Nomenclature of lower limb veins

Veins of extremities are very numerous. Different venous groups can be found depending on their position with respect to muscular fasciae. Deep venous system can be found underneath the fascia. Superficial venous system can be found above the muscular fascia. Perforating venous groups communicate the two by perforating the fascia. A new nomenclature has come up to provide the numerous veins of lower extremities with uniformity by abolishing confounding expressions with respect to the position of the aforementioned vein, thus avoiding excessive eponyms. The following tables show the equivalence between old and current nomenclatures. We made different categorizations into deep venous system (table I), superficial venous system (table II) and perforating veins (table III) and adapted them to the ones we believe are commonly used (8,9).

Anatomy applied to lower limb venous ultrasound

Deep venous system

We'll be briefly summarizing the findings and mechanics of ultrasound venous studies of major venous

Table I. Equivalence of old and current nomenclature of deep venous system veins

Deep venous system	
Old nomenclature	**Consensus nomenclature**
Common femoral vein/ Femoral vein	Common femoral vein
Superficial femoral vein	Femoral vein
Deep femoral vein	Deep femoral vein
Popliteal vein	Popliteal vein
Anterior tibial vein	Anterior tibial vein
Posterior tibial vein	Posterior tibial vein
Peroneal vein	Peroneal vein
Sural veins	Sural veins
	– Soleus veins
	– Gastrocnemius or calf muscle veins
	– Inter-calf muscle veins
	Lateral plantar vein
	Medial plantar vein
	Plantar venous arc

Table II. Equivalence of old and current nomenclature of superficial venous system veins

Superficial venous system	
Old nomenclature	**Consensus nomenclature**
Internal saphenous vein, long or major	Great saphenous veins:
Anterior saphenous vein	Anterior accessory vein of great saphenous vein
Posterior accessory vein or Leonardo's vein	Posterior accessory vein or great saphenous vein
External saphenous vein, short or minor	Small saphenous vein
Intersaphenous communicating vein	Posterior thigh circumflex vein or Giacomini vein

Table III. Equivalence of old and current nomenclature of perforating veins

Perforating veins	
Old nomenclature	**Consensus nomenclature**
	Gluteal perforating veins:
	– Superior
	– Medial
	– Inferior
	Thigh perforating veins:
	– Perforating veins in the inguinal region
Hunter or Dodd perforating veins	– Perforating veins of femoral canal
	– Anterior thigh perforating veins
	– Lateral thigh perforating veins
	– Sciatic perforating veins
Hach perforating veins	– Posterolateral perforating veins
	– Pudendal perforating veins
	– Leg perforating veins
Cockett perforating veins	– Posterior perforating veins of superior, medial, and inferior tibia or Cockett perforating veins
Boyd and Sherman perforating veins	– Anterior and lateral perforating veins
Bassi and May perforating veins	– Posterior perforating veins of lateral and medial gastrocnemius muscles

segments. In the first place, veins of the deep venous system will be described (6,10,11).

The first segment that should be studied on the ultrasound anatomy is the iliac venous axis that is not always taken into consideration in venous ultrasound studies of lower extremities. This is due to certain peculiarities associated with its study like the need to conduct it in the decubitus prone position or the need to conduct it with a low-frequency transducer often in the longitudinal view as opposed to the remaining venous study of lower extremities. Also, its assessment is not essential for the proper study of lower extremities. However, it is not easy to spot on the ultrasound or follow the venous axis that runs parallel and underneath the homonymous arterial axis. It is a long and tortuous venous axis that, apart from the aforementioned association with the iliac arterial axis, is associated with the pelvic floor on which it stands. With the proper view and in favorable anatomies, even the first centimeters of the hypogastric vein can be examined.

Located underneath the inguinal ligament, the iliac vein changes its name to common femoral vein. It is, therefore, a short structure of nearly 4 cm to 60 cm in length and of superficial and internal location to the groin and common femoral artery, respectively. This vein is the result of the confluence of the thigh two most important deep venous structures: femoral vein and deep femoral vein. Also, the great saphenous vein drains into the deep venous system at common femoral vein level. This meeting point is called the saphenofemoral junction. Together with the superficial and deep femoral arteries, in its first few centimeters, the saphenofemoral junction adopts a characteristic B-mode ultrasound image and cross-sectional view. This image resembles Mickey Mouse head, and it called the Mickey Mouse sign. The face of the mouse is the common femoral vein, its 2 ears are the superficial and deep femoral arteries, and the nose is the saphenofemoral junction. This is home to the saphenofemoral valve that is so important to assess venous studies of extremities.

Deep femoral vein can be assessed on the ultrasound in its previous centimeters before it meets the common femoral vein. It is not always necessary to study it, but with the current ultrasound probes its insonation is possible. Its characteristic direction is parallel to the ultrasound beam with anteroposterior direction being deep with respect to the homonymous artery.

Femoral vein is one of the longest in the body. It runs through the thigh internal compartment underneath the sartorius muscle. It is associated with the superficial femoral artery in its entire trajectory: in the thigh proximal centimeters, the superficial femoral artery is external to the femoral vein while in the rest of the trajectory, the artery looks superficial to the vein.

Femoral vein is also associated with the deep femoral artery in the centimeters proximal to the thigh being the vein superficial to the artery.

The passage of femoral vein through the adductor canal or Hunter's canal is the reason why the name of this vessel has been changed into popliteal vein. This venous structure is often duplicated. It is associated with its homonymous artery running deep and superficial to the artery in its supra- and infra-genicular portions, respectively. Also, the popliteal vein is closely associated with 2 bone structures —the femoral condyles and the tibial plateau— that can easily be identified on the B-mode ultrasound in the longitudinal view. It has several collaterals since several genicular venous groups drain into it. Finally, and as a really significant association, the upper infra-genicular segment of popliteal vein drains into the small saphenous vein deep venous system.

Posterior tibial veins are easy to test on the ultrasound and can be found posterior to the internal malleolus. They are closely associated with their homonymous artery and can be double and even triple. They ascend through the leg internal facet and are closely associated with the thigh internal muscle until they drain into the popliteal vein.

Anterior tibial veins can be found at malleolar level in the ankle anterior aspect and are associated with its homonymous artery. They are often double or triple. They ascend deep into the leg anterior compartment and over the interosseous membrane. At fibula level, veins posteriorly run through the interosseous membrane to finally drain into the popliteal vein.

Double or triple fibula veins are found posterior to the external malleolus in the left lower third. They keep a close association with their homonymous artery and ascend through the leg external and posterior aspect towards the popliteal vein. Apart from the artery, fibula veins are closely associated with the external calf muscle and the fibula bone.

We should not end this section on lower limb deep venous structures without commenting on the very last structure we should check while performing the ultrasound assessment: soleus and calf muscle veins. Their distribution is a little more erratic and are located inside the soleus or calf muscles without accompanying homonymous arteries.

Superficial venous system

We will now be describing the ultrasound anatomy of lower extremity veins of superficial venous system (6,10-12).

The great saphenous vein runs through the thigh and leg in its internal side superficial to the muscular fascia and wrapped around a fold of the latter inside what is called the "eye of the great saphenous vein". The internal malleolus found at malleolar level ascends vertically through the described region, retrogenicularly, towards the aforementioned saphenofemoral junction.

The anterior accessory vein of the great saphenous vein occupies an anterior segment in the muscle and is also wrapped around a fold of the muscular fascia. It drains into the saphenofemoral junction. There are times when it can be mistaken for the great saphenous vein. The main difference between the two is the correlation established between the anterior accessory vein and the femoral vascular bundle. The anterior accessory vein is located at the same level of this femoral vascular bundle while the great saphenous vein can be found at a more internal location with respect to the femoral vascular bundle.

The small saphenous vein runs vertically through the entire leg in its posterior side. It is found in the external malleolus, posterior to it, and ascends through this region towards the saphenopopliteal junction. Same as it happens with the great saphenous and anterior accessory veins the small saphenous vein is wrapped around in its own fascia.

METHODOLOGY OF LOWER LIMB VENOUS ULTRASOUND ASSESSMENT

The methodology of lower limb venous ultrasound assessment allows us to assess all structures and entities listed to this point (5,7).

We should consider that unlike it happens in other vascular studies, no high-end specific ultrasound probes are required for lower limb venous assessment. Therefore, with a simple Doppler ultrasound probe we should be able to make basic assessments of the veins of extremities. Basic venous ultrasound studies are performed using a linear transducer that emits medium-to-high frequencies (7-12 MHz). This allows us to assess both the femoropopliteal and distal axes, as well as the saphenous axes. However, some venous segments can require transducers with greater penetration capabilities like curved transducers that emit medium-to-high frequencies (3 MHz to 5 MHz). As a matter of fact, curved transducers are essential to assess the venous iliac axis. Also, in obese patients it provides better images of the deep femoral vein, supragenicular popliteal vein, and confluence between the anterior tibial vein and the tibiofibular venous trunk that makes up the popliteal vein. The more suitable ultrasound probe parameters for vein assessment should be selected by the operator. Each ultrasound probe comes with several parametric models for venous studies. Overall, the idea is to increase the sensitivity of our machine as much as we can to assess slow flows. Therefore, color gain should be increased on the color Doppler ultrasound, filters should be attenuated, and the frequency of pulse repetition should be reduced on the pulsed wave Doppler ultrasound. The sample volume on the pulsed wave Doppler ultrasound should reach the entire lumen of the vein to better capture its entire flow.

Venous studies should be performed with the patient while in bipedal stance. This is the only way to assess the characteristics of venous flow. The decubitus position is only accepted when assessment is conducted to discard thrombotic processes. In this case, for the sake of the patient's own comfort and because the state of flow is not a concern, lying down is beneficial for the patient. Similarly, the supine decubitus position is required to assess the iliac venous access.

Regarding the direction of assessment, the reasonable thing to do is to conduct a cranial-to-caudal assessment of the femoropopliteal sector and veins of the superficial venous system. However, to assess distal veins like the iliac axis, it is easier to conduct a caudal-to-cranial assessment since it is easier to locate the venous structures described distally and assess them proximally. The vessel longitudinal follow-up is not required since flow characterization can be seen on a cross-sectional assessment that is easier to conduct. We should mention that for proper flow visualization in the cross-sectional view a Doppler probe with a certain angulation should be applied to the target extremity. Only in the iliac sector, longitudinal assessment of the iliac venous axis is advised for follow-up purposes. Bilateral assessment of the alterations found is advised for comparison purposes.

Assessment should start on the B- or gray scale mode. This imaging modality allows us to assess morphological alterations that can damage the lower limb superficial or deep venous system. Here are some of the alterations we can find:

- Vein morphology.
- Venous duplicities.
- Determine venous diameters.
- Anomalies in the position of the veins and alterations in the associations of these with neighboring structures.
- Vein lumen occupation.
- Thickenings or irregularities of venous walls.
- The compressibility, or not, of the target venous vessel can be confirmed through a simple compression maneuver of the insonated venous structure with the transducer.

Table IV shows the morphological findings provided by the ultrasound assessment of lower limb venous insufficiency.

After the aforementioned early morphological assessment, on the B-mode, venous flow should be assessed using the Doppler technique. Two different versions of Doppler can be used here: color Doppler mode and pulsed wave Doppler. The former provides an easier and more direct use. It is, however, less sensitive compared to the latter regarding flow assessment. Hemodynamic assessment can reveal:

Table IV. Ultrasound hemodynamic findings of venous insufficiency

Morphological findings
Morphology of veins
Venous duplicities
Venous diameters
Anomalies in the position of the veins
Alterations in relation to neighboring structures
Vein lumen occupation
Thickening or irregularities of venous walls
Compressibility, or not, of venous vessel

- The presence of flow, spontaneous or not, in the vein under study.
- The presence, or not, of the phenomenon of respiratory modulation or phascitity of venous flow. The presence of this modulation translates the absence of occlusive pathology between the insonated segment and the right atrium.
- The presence or absence of reflow in the insonated vein. The presence of this reflow will define venous insufficiency.

Table V shows the hemodynamic findings provided by the ultrasound assessment of lower limb venous insufficiency.

There are very many maneuvers that can demonstrate the presence of reflow:

- Valsalva maneuver: it is meant to trigger an increased intra-abdominal pressure. The presence of reflow in the insonated vein will be shown on the Doppler color function, whether color or pulsed, as an increased flow with directionality opposed to spontaneous venous flow. The lack of reflow can be seen as an absence of flow during the Valsalva maneuver. This maneuver is especially useful in the iliac venous axis, femoral venous axis, saphenofemoral junction, proximal half of the great saphenous vein, and anterior accessory vein of the great saphenous vein. However, it is not as evident in popliteal, distal sectors or in the small saphenous vein.
- Paraná maneuver: it allows us to confirm the presence of venous reflow in all sectors in a closer way to the physiological event. A gentle push to the person being examined triggers a small muscular contraction of stabilization in response to such push. Such muscular contraction produces, in a non-pathological situation of the vein under assessment, an increased flow wave in cardiopetal direction followed by flow cessation with final muscular relaxation. However, in the presence of venous structure reflow after the increased flow wave with muscular contraction, a flow wave in cardiofugal direction will be seen while in muscular relaxation.
- Distal muscular compression maneuver: this maneuver does not trigger the patient's reflex muscular contraction. Instead, it is the operator who compresses the muscular mass distal to the target vein to assess the venous flow response obtained. In a non-pathological vein, an increased venous flow —a phenomenon called positive A-wave— should be confirmed followed by a lack of flow. However, the presence of reflow will trigger an inverse wave to cardiopetal venous flow when relaxing compression.

Muscular compression maneuvers —the Paraná maneuver too— indirectly help us confirm the presence of vessel obstructions in the target vein and the contracted muscular mass: in case of flow obstructions, muscular compression won't be causing the anticipated increased venous flow, the so-called negative A-wave.

Table VI summarizes the maneuvers of venous reflow assessment.

Table V. Ultrasound morphological findings of venous insufficiency

Hemodynamic findings
Presence of flow, spontaneous or not
Presence of the phenomenon of respiratory modulation or phasicity of venous flow
Presence or lack of reflow in insonated vein

Table VI. Summary of the assessment maneuvers of venous reflow

Maneuver	Characteristics
Valsalva	Useful in the proximal sector
Paraná	Physiological
	All sectors
	Indirect confirmation of distal occlusions
Muscular compression	The most commonly used
	Indirect confirmation of distal occlusions

SEQUENCE OF ULTRASOUND ASSESSMENT OF LOWER LIMB VEINS

This section provides an assessment sequence model of lower limb veins in observance of all the recommendations mentioned above (13).

Examination starts with the patient facing the operator while exposing his lower limb anterointernal region. Examination starts by assessing the great saphenous vein thigh middle third region to see its diameter, intrafascial location, or not, lumen occupation, compressibility, presence of flow and reflow. By directing the transducer towards the most anterior segment of the thigh middle third region, the femoral vein is assessed in these same parameters. The presence of duplicities, if any, and the correlation between the vein and its homonymous artery are studied as well. Parameters associated with the anterior accessory vein of the great saphenous vein in this same thigh middle third region are studied in the same view as the femoral vascular bundle —superficial to it— and above the muscular fascia. Afterwards, the transducer is fixed to the groin region where the common femoral vein and the saphenofemoral junction should both be assessed regarding morphology, lumen occupation, and presence of reflow using the Valsalva or Paraná maneuvers in the common femoral vein, saphenofemoral junction or nearby regions: ostial o paraostial reflow, respectively. Assessing the entire length of both the femoral and anterior accessory veins of the great saphenous vein following the early assessment of the thigh middle third region is optional though advised. Still, it is spared in a standard assessment to shorten examination times in all those cases when the assessment of the thigh middle third region shows no pathological findings. However, the entire length of the great saphenous vein should be assessed from the groin region up to the malleolus in the same aforementioned parameters —an assessment that is performed at this point. The final assessment that will be conducted with the patient in this position is the assessment of tibial veins from the malleolus up to the knee— the same aforementioned parameters of position, correlation with the homonymous artery, number, lumen occupation and compressibility, presence of flow, increased flow wave with muscular compression, and presence, or not, of reflow will be assessed too.

Afterwards, the patient is placed with his back facing the operator. There are times that the examination can be easier if the patient flexes the knee of the target extremity a little bit. While in this position, the transducer is placed on the popliteal fossa to assess the popliteal vein in the aforementioned parameters. While the transducer remains on this same position, the saphenopopliteal junction is studied regarding compressibility, lumen occupation, presence of flow and increased flow with muscular compression and reflow with muscular relaxation or the Paraná maneuver. While the transducer is in this same position now on the popliteal fossa, the entire length of the small saphenous vein is examined down to the malleolus with the same items. The last venous structures that should be assessed while in this position are the soleus and calf muscle veins by tracking them down with the transducer on the calf. The usual parameters are assessed here: compressibility lumen occupation, presence of flow and reflow.

Table VII summarizes all the items that should be assessed during the ultrasound assessment.

LOWER LIMB VENOUS THROMBOSIS ASSESSMENT THROUGH DOPPLER ULTRASOUND

There are 5 different ultrasound signs that should be assessed to diagnose limb venous thrombosis.

1. B-mode or gray scale confirmation of venous lumen occupation following the presence of hyper- or hypo-echogenic material.
2. Vein lumen occupation due to thrombotic material leading to the ultrasound manifestation —in gray scale— of the most specific sign of venous thrombosis, that is, the lack of venous compressibility with the transducer. This lack of compressibility can also be due —although without evidence of occupied venous lumen— to the venous plethora that can be created due to proximal obstructions of the target venous segment.
3. Regarding the assessment of venous flow in a thrombotic process, this is abolished both on the B-mode and on the pulsed wave Doppler in the ultrasound assessment of a thrombosed vein. Also, as indirect signs of thrombosis, there are 2 data available in flow assessment that allow us to achieve this diagnosis.
4. The lack of respiratory modulation or phasicity in flow assessment on a venous spot can translate

Table VII. Assessment of each vein in the assessment sequence proposed

	Diameter	Intrafascial or not	Lumen occupation	Compressibility	Flow	Reflow	Duplicity	Arterial relation
Great saphenous vein	✓	✓	✓	✓	✓	✓	✓	
Femoral vein		✓	✓	✓	✓	✓	✓	✓
AAGSV	✓	✓	✓	✓	✓	✓	✓	
Common femoral vein			✓	✓	✓	✓		✓
Saphenofemoral junction			✓	✓	✓	✓		
Tibial veins			✓	✓	✓	✓	✓	✓
Popliteal vein			✓	✓	✓	✓	✓	✓
Saphenopopliteal junction			✓	✓	✓	✓		
Small saphenous vein	✓	✓	✓	✓	✓	✓	✓	
Calf muscle veins			✓	✓	✓	✓		

AAGSV: anterior accessory great saphenous vein.

the obstruction of the venous sector between the right atrium and the insonated vein.

5. The lack of A-wave enhancement to muscular compression in the insonated region explains the presence of a possible obstruction between the target region and the area of muscular compression (14).

Several protocols can be used to assess patients with suspected thrombosis:

- Minimum assessment based on the compression of 2 or 3 spots of the deep venous tree, specifically, the common femoral vein (above), the saphenofemoral junction (underneath), and the popliteal vein.
- A more extended version including assessment through ultrasound compression of the entire common femoral vein, the femoral vein, and the popliteal vein.
- Performance of an ultrasound with compression of the entire femoropopliteal axis including the distal veins, and the soleus and calf muscles. We should mention how difficult it is to detect new thrombotic phenomena in these distal structures, which can produce false negatives in the ultrasound assessment.
- The best option of all: Add to the compression assessment of femoropopliteal and distal veins, flow assessment using the Doppler function of, at least, the common femoral vein, the saphenofemoral junction, and the popliteal vein. This is the most accurate way to assess the thrombotic phenomenon. Also, it allows indirect —also more accurate assessments— of the iliac axis since the lack of respiratory modulation during the Doppler assessment of the common femoral vein is suggestive of a possible occlusion of this venous sector.

Any of the first three alternatives, though easier to perform, faster, and more available for any working group, are no stranger to insecurities in such a way that with doubtful or suspected clinical signs, the assessment needs to be repeated within the following 7 days after the index assessment (15,16). The sensitivity and specificity of a limited ultrasound assessment is 90.1 % and 98.5 % respectively. However, these same parameters in an extended assessment reach 94 % and 97.3 % respectively. Serial assessments increase the reliability of these assessments up to a 97.9 % sensitivity and a 99.8 % specificity (15,16).

The two venous sectors where an accurate diagnosis of thrombosis is more difficult to achieve are the iliac venous axis and the distal venous vessels. The former is not often assessed on a routine basis in venous thrombosis assessments unless there are clinically suggestive signs or else the presence of common femoral vein thrombosis or lack of respiratory modulation on the Doppler ultrasound assessment of the common femoral vein. Venous compression maneuver, so useful in other assessments due to suspected thrombosis of venous vessels is not so feasible in this territory and needs to be assessed by confirming the presence of vein lumen occupation, lack of spontaneous flow, and lack of A-waves and respiratory modulation. This reduces the effectiveness of Doppler ultrasound at this level. Therefore, the use of axial coronary computed tomography angiography or nuclear magnetic resonance imaging is essential for the accurate diagnosis of iliocaval thrombosis. Infragenicular veins are not difficult to assess with modern ultrasound probes. However, there are times that the isolated thrombosis of some infragenicular venous groups is not taken into consideration regarding its routine assessment and can go misdiagnosed in a limited assessment due to suspected thrombosis (14-16).

One of the most interesting and difficult things to assess in a Doppler ultrasound performed to assess venous thrombotic process is the dating of the actual age of the thrombus. Therefore, a recent thrombosis will give us the image of an anechoic or hypoechoic homogeneous thrombus and with relative elasticity of such thrombus, that is, without collapsing venous lumen a certain deformability of such lumen is confirmed. Also, an increased diameter of the insonated vein is often seen here too. With the temporal evolution of thrombus, it gains echogenicity, becomes more palid in color, more heterogeneous, and with less elasticity of thrombus to compression. The diameter of the thrombosed vein decreases. In chronic stages of the disease, total venous vessel recanalization without residual reflow can occur or else, recanalization with final venous insufficiency. On the other hand, there are cases of absolute lack of this recanalization. Finally, chronic stage consists of a partial recanalization of venous lumen with vascular wall thickening due to a scarring process of the thrombotic phenomenon with presence, or not, of venous reflow (15,17).

ASSESSMENT OF PELVIC VENOUS INSUFFICIENCY

Definition of the clinical signs

Pelvic venous insufficiency is defined as a series of chronic symptoms that can include pelvic pain, perineal discomfort, urinary urgency, and pain after intercourse due to reflow and/or pelvic and gonadal vein obstruction. It can be associated with varicose veins in the external genital, perineal or lower extremity regions. The origin of pelvic venous insufficiency is found in reflow phenomena that affect the gonadal veins purely, which has been called primary pelvic venous insufficiency. Or else, it is due to compressive phenomena of the left renal vein —the so-called Nutcracker syndrome— or the left common iliac vein —the so-called May Thurner syndrome— overall called secondary pelvic venous insufficiency. Also, within the pathophysiology of this entity, pelvic venous insufficiency can be due to iliocaval thrombotic phenomena and their sequelae. Clinical signs of this entity are highly unspecific, which makes patients want to visit several specialists with eventually little or no success at all. It often affects multiparous women between the age of 20 and 40 with a 6-month history of constant, non-cyclic dull aching pelvic pain unrelated to the period. Symptoms often become worse at the end of the day with sexual relations, before the period, and with prolonged sitting or standing. However, they improve in the decubitus position. Main symptoms can be accompanied by dysmenorrhea, dyspareunia, back pain, and presence of pelvic, vulvar varicose veins, of atypical distribution, and often relapses if patients have undergone previous surgeries (18-21). There are certain clinical features of the Nutcracker syndrome other than the aforementioned signs and symptoms. In conclusion, the presence of renal hypertension, macroscopic or microscopic hematuria and proteinuria (22). Similarly, there is additional symptomatology in the May Thurner syndrome: symptoms of left lower limb chronic venous insufficiency in young patient with pain and edema in that extremity, presence of varicose veins of atypical distribution, even appearance of associated skin trophic changes, and even trophic lesions of venous stasis in left lower limb, and finally episodes of left lower limb deep venous thrombosis (23).

Doppler ultrasound in the management of pelvic venous insufficiency

The first step in the assessment of pelvic venous insufficiency is to achieve diagnostic orientation through clinical signs regardless of how unspecific these may seem on the Doppler ultrasound. Gray-scale Doppler ultrasound and color flow Doppler, and pulsed wave Doppler modes provides significant information on pelvic venous insufficiency. They do so from a morphological and hemodynamic standpoint and always from a non-invasive approach. They assess patients in the standing position. In this entity, this is extremely useful since bipedalism exacerbates the morphological and hemodynamic alternations that cause the clinical signs. We should mention that in female pelvic venous insufficiency assessments, performing transvaginal Doppler ultrasound can help since it reveals venous pathological findings in pelvis and the perigonadal region much easier. However, its performance and interpretation don't fall within the competence of our diagnostic test labs and, therefore, won't be developed here.

Although the ultrasound signs suggestive of pelvic venous insufficiency are varied, they have not been established profoundly. Pelvic venous insufficiency is characterized by the presence, on the B-mode ultrasound, of periuterine tubular venous structures —or else directly pelvic— with diameters > 5 mm to 6 mm, multiple and unilateral o bilateral. The application of Doppler mode, whether color or pulsed, on these structures allows the characterization of the structures venous flow. This flow appears increased although the measurement of flow velocities reveals the slowing down of such velocities (not > 3 cm/second). On the other hand, always in Doppler mode, whether color or pulsed, the Valsalva maneuver confirms the reflow of pelvic tubular venous structures described > 1 msec. Gonadal veins also show characteristics of pelvic venous insufficiency. In particular, gonadal vein dilatation ≥ 6 mm would be pathognomonic of this structure venous insufficiency. The Doppler assessment of these venous structures is again characterized by the existence of spontaneous reflow. Reflow is important and continuous in the entire respiratory cycle, although modulated by it in case of primary pelvic venous insufficiency. Also, it increases significantly with the Valsalva maneuver. However, when the presence of stenotic or obstructive pathology is confirmed as the cause of pelvic venous insufficiency, reflow —though spontaneous— is much milder, continuous throughout the entire respiratory cycle, although without respiratory modulation or increase with the Valsalva maneuver. The ultrasound sensitivity for the detection of gonadal veins is 100 % in the case of the left one and 67 % in the case of right one.

The Nutcracker syndrome shows several ultrasound parameters that allow us to achieve its diagnosis. Through B-mode Doppler ultrasound it is possible to detect, in the first place, the presence of the retroaortic left renal vein —a rare anatomical variant— that affects 2 % of the population and is clearly associated with this syndrome. In the same gray scale mode, it is possible to measure the aortomesenteric angle being a criterion of the Nutcracker syndrome acute angulations < 20° or 40° according to different articles. Also, it is possible to determine the diameters of the left renal vein both in the same aortomesenteric clamp and previous to it. Ratios ≥ 5 between both diameters mark the presence of this entity. The origin, in the left renal vein, of the gonadal vein is also easy to identify in the Nutcracker syndrome. The identification of the latter and the determination of its diameter > 5 mm or 6 mm is also indicative of the presence of this syndrome. In pulsed wave Doppler, maximum velocities in left renal vein, the territory of the aortomesenteric clamp, and in the segment previous to it can be determined. Velocity ratios > 3 or 3.5 are determinant of the presence of this disease (20,21,24). With all these parameters explained, the sensitivity and specificity of the Doppler ultrasound for the diagnosis of the Nutcracker syndrome is 69-90 % and 89 %-100 %, respectively (22).

The May-Thurner syndrome can be detected on the Doppler ultrasound with a sensitivity that is clearly inferior to the former. The B-mode Doppler ultrasound in May-Thurner syndrome is characterized by the presence of left iliac venous axis dilatation, although there are no clear criteria of significance. Venous flow can be assessed using the Doppler function. In May-Thurner syndrome it is slowed down compared to contralateral flow, almost without respiratory modulation and, typically, with inverted flow in the homolateral hypogastric vein (24).

Table VIII shows the ultrasound findings of pelvic venous insufficiency

Here follows a possible methodology for the ultrasound assessment of pelvic venous insufficiency. The patient should be meticulously examined in the supine decubitus position. Also, it requires fasting for, at least, 6 hours. The use of high-performance ultrasound probes is necessary for proper abdominal resolution. The test is performed with a convex low-medium frequency probe (3 MHz to 5 MHz) since this examination aims at the abdominopelvic cavity. There are no specific programs for this type of venous examinations. We should mention here the need for an adequate contrast in B-mode or gray scale, which is often achieved by increasing dynamic range, minimizing the frequency of pulse repetition, and increasing gain in color or pulse Doppler modes to capture minimum flows in the target venous structures. Here is something we should mention regarding color Doppler ultrasound: excessive color Doppler alters the perception of flow in the target venous structures by clouding the big picture with an excess of color. Balance between the need to add this color Doppler effect to the image for better assessment and the excess image artifacts produced due to excess color should be achieved.

A possible assessment sequence would be:

1. Finding, in transverse direction, in the supraumbilical and mid-abdominal regions, on B-mode and, if necessary, on color Doppler ultrasound the abdominal aorta at renal artery level.
2. Detection —right of the aorta and left to the ultrasound probe screen— of the inferior vena cava, its position, and using Doppler function, its patency and respiratory modulation of its flow.
3. The identification of the superior mesenteric artery in its origin at the anterior aortic side. At this point, aortomesenteric clamp is established through which the left renal vein runs. By plac-

Table VIII. Ultrasound findings in pelvic venous insufficiency

Findings in pelvic venous insufficiency		
Primary pelvic venous insufficiency		
Parauterine veins	B-mode	Multiple periuterine tubular venous structures —or directly pelvic— with > 5 mm to 6 mm diameters
	Doppler	Increased flow at slow velocities not exceeding 3 cm/seg.
		Valsalva: reflow > 1 msec
Gonadal veins	B-mode	Diameter ≥ 6 mm
	Doppler	Spontaneous reflow in the entire cycle
		Valsalva increases reflow
Secondary pelvic venous insufficiency (added to the aforementioned…)		
Nutcracker syndrome	B-mode	Retroaortic left renal vein Mesenteric aortic angle < 20° to 40° Diameter ratio ≥ 5
	Doppler	Ratio of peak venous velocities ≥ 3 to 3.5
		Vasalva slightly increases reflow in left gonadal vein
May Thurner syndrome	B-mode	Dilatation of left iliac axis
	Doppler	Venous flow in slowed left iliac axis compared to the right one without respiratory modulation and inverted flow in left hypogastric vein
		Vasalva slightly increases reflow in the left gonadal vein

ing the ultrasound probe in the longitudinal position and obtaining images in the sagittal view of aortomesenteric clamp the angle of such clamp can be measured.

4. Assessment of left renal vein. This assessment should cover the aortomesenteric clamp and a site distal to it. The B-mode ultrasound describes the occupation, or not, of the vein lumen, facilitates measurement of venous diameter in the aortomesenteric clamp and prior to it, and establishes its ratio. The application of the color Doppler ultrasound confirms the presence or absence of flow in the left renal vein. Finally, the pulse Doppler function can be used to obtain the objective parameter of flow velocity in the left renal vein in the clamp and previous to it and establish its ratio.
5. Identification of left gonadal vein: follow-up —always in the cross-sectional view and with gray scale or color Doppler ultrasound— of left renal vein to identify its origin and be able to study it.
6. Follow-up of left gonadal vein in the cranial-to-caudal direction and in the cross-sectional view while keeping its location prior to the left psoas muscle as the reference. Its diameter is estimated on the B-mode ultrasound. Using Doppler function, color or pulsed, the presence of flow in the vessel, its respiratory modulation, presence of reflow, and its behavior with the Valsalva maneuver can be confirmed.
7. Identification and follow-up of right gonadal vein located in the right psoas muscle anterior region. Its diameter is estimated on the B-mode ultrasound. Using Doppler function, color or pulsed, the presence of flow in the vessel, its respiratory modulation, presence of reflow, and its behavior with the Valsalva maneuver can be confirmed.
8. Assessment of iliac venous axes. Iliac axes can be assessed in the cross-sectional view. However, its longitudinal view is more logical somehow because it also allows better visualization of the hypogastric vein. The assessment of both iliac axes is essential to establish the differentiation or analogy between the two. Once again, here the B-mode allows us to confirm vein lumen occupation by thrombotic material. Also, it allows us to determine the diameters at stake. Also, the application of the Doppler mode allows us to confirm the presence or absence of spontaneous flow, its greater or lower modulation with the respiratory phenomenon, and the directionality of this flow. Pulsed wave Doppler can be used to determine flow velocities in the target venous segment.
9. Assessment of periuterine venous structures with transducer in the hypogastric region. It should be performed on B-mode to detect its presence and measure its number and diameter. Afterwards, the Doppler mode should be applied to assess its flow—at low velocities in the pulsed wave Doppler mode—and the presence of exacerbated reflow with the Valsalva maneuver.
10. After the examination has been completed and in cases of suspected Nutcracker syndrome the aforementioned assessment maneuvers on the left renal vein need to be repeated while the patient is in the standing position since this position reveals almost all the ultrasound parameters described for this syndrome.
11. One last episode in the ultrasound assessment of pelvic venous insufficiency is thelower limb venous Doppler ultrasound we've already explained in a different section of this document while paying special attention to the pelvic leak points that cause superficial venous insufficiency of lower limbs. (24,25).

Table IX shows this assessment sequence.

Other non-invasive studies of pelvic venous insufficiency

Other useful non-invasive imaging modalities to assess pelvic venous insufficiency include axial computed tomography and nuclear magnetic resonance imaging. Their main advantage compared to Doppler ultrasound is the overall assessment of the abdominopelvic cavity they facilitate. Also, in suspicious case reports, they provide images of other possible diagnoses plus detailed anatomy of the aforementioned iliocaval venous lesions for better therapeutic planning. Both assessments are far from perfect, depend

Table IX. Sequence of ultrasound assessment of pelvic venous insufficiency

Assessment sequence
1. Location of abdominal aorta in renal arteries
2. Detection and assessment of inferior vena cava: – Position – Patency – Respiratory modulation
3. Detection of aortomesenteric clamp and left renal vein: – Measurement of aortomesenteric angle
4. Assessment of left renal vein: – Lumen occupation – Measurement of diameters and ratio – Determination of maximum venous velocities and measurement of ratio
5. Identification of left gonadal vein: – Cranial-to-caudal direction – Cross-sectional – Measurement of diameters – Presence of flow – Respiratory modulation – Valsalva
6. Identification of right gonadal vein: – Cranial to caudal direction – Cross-sectional – Diameter measurement – Presence of flow – Respiratory modulation – Valsalva
7. Assessment of venous iliac axes: – Longitudinal – Bilateral – Lumen occupation – Diameter measurement – Presence, or not, of spontaneous flow – Respiratory modulation – Direction of flow – Determination of velocities
8. Assessment of periuterine venous structures: – Presence – Number – Diameter – Increased flow at low velocities – Increased reflow with Valsalva
9. If suspected Nutcracker syndrome repeat the assessment of left renal veins in bipedal stance
10. Standard vein study of the lower limbs

on the machine being used, volume, distribution of contrast, and even the processing and treatment of the images obtained. Also, we can only use them with the patient in the decubitus position, not in the standing position. Axial computed tomography is more affordable, can be used much faster, is more widely available, and is easier to interpret. The advantage of nuclear magnetic resonance imaging is that it does not use ionizing radiation or contrast, and facilitates the hemodynamic assessment of venous flow. Same as with the Doppler ultrasound these imaging modalities allow us to assess compressive phenomena like the Nutcracker and May-Thurner syndromes. These studies allow us to determine the position of left renal vein and its diameters in the aortomesenteric clamp and previous clamp and then establish a ratio between the two for the diagnosis of the Nutcracker syndrome, usually ≥ 5. Through sagittal view reconstructions, they provide objective measurements of the aortomesenteric angle, pathological if < 20-40°. They allow us to conduct morphological assessments of left common iliac vein compression between the right common iliac artery and the spine, a distinctive feature of the May-Thurner syndrome. Both assessments are particularly useful to detect, find, and assess gonadal veins to plan future catheterizations of these. Therefore, they define with great accuracy the presence of dilated pelvic venous plexuses so typical of pelvic venous insufficiency (20-25).

Phlebography in pelvic venous insufficiency

Phlebography is considered the gold standard for the diagnosis, study, and therapeutic planning of pelvic venous insufficiency. It is often not only a diagnostic procedure, but also one performed, in most cases, with therapeutic purposes. It is not easy to perform or interpret due to the intricacy, low pressures, slowness, and breathing changes associated with venous flow, and the volume of contrast it requires. In addition to morphological assessments, phlebography also allows us to determine IV pressures, an extremely useful parameter to diagnose and confirm the presence of pelvic venous insufficiency. In the Nutcracker syndrome, the presence of an IV pressure gradient between the inferior vena cava and the left renal vein distal to the superior aortomesenteric clamp > 3 mmHg is diagnostic of this entity being gradients < 1 mmHg normal. Other phlebographic signs of the Nutcracker syndrome are the confirmation of an imprint in the left renal vein lumen exerted by the superior mesenteric artery, the dilatation of the left renal vein prior to this imprint, and the appearance of anomalous drainage pathways in the left renal vein including a specially dilated left gonadal vein. Also, it is possible to make very accurate measurements of the aortomesenteric angle. The May-Thurner syndrome is also characterized by an unusually elevated pressure gradient between the inferior vena cava and the left iliac axis distal to compression being values ≥ 2 mmHg truly alarming. Other signs to consider phlebography when assessing the May-Thurner syndrome would include flow reversal in the left hypogastric vein and the usual pre-stenotic dilatations of the left iliac venous axis plus the presence of abundant pelvic venous collaterals of anomalous drainage. Primary pelvic venous insufficiency due to damaged gonadal veins reveals phlebographic signs of known dilatations of pelvic veins with values > 5 mm in diameter, tortuous morphology with contrast retention in the dilatations, and appearance of anomalous venous drainage in pelvic, lower back, and lower limb regions (20-25).

Intravascular ultrasonography in pelvic venous insufficiency

We should not finish the description of the diagnostic imaging modalities of pelvic venous insufficiency without mentioning the possibly best diagnostic tool in this field of vascular pathology. We are talking about intravenous ultrasonography. It is an invasive assessment that requires, on the one hand, radiation for intravenous progression, but also based on ultrasonographic concepts so familiar in our medical specialty. It provides parietal and luminal images of the target vein in its entire thickness, the insonated segment and, above all, in the 360º of the circumference of the vein. It offers multiple advantages. In the first place, for an overall visualization of a venous segment even the phlebographic gold standard would require a tremendous number of views with intolerable high doses of radiation and need for contrast especially taking into consideration the venous anatomy of a section of the vessel not completely circular, but elliptical, and mobile with breathing. Therefore, with intravenous ultrasonography we are reducing radiation, contrast, and procedural time. However, ironically, we are increasing the accuracy of both the diagnostic and therapeutic measures obtained: location of the origins of veins, collaterals, gradation of stenotic regions with greater accuracy in the selection of intravascular devices. Its only formal disadvantage would be its high cost and the learning curve required. Overall, severe stenosis is defined as a 70 % occlusion of venous region or if the difference between venous regions in the target stenosis and the healthy previous segment is > 60 %. Intravascular ultrasonography —with its accuracy estimating the area of the stenosed venous segment— establishes a ratio compared to the previous segment and has become —together with the phlebographic assessment of pressure gradients— the gold standard for the diagnosis of the Nutcracker syndrome. In the May-Thurner syndrome, the use of intravascular ultrasonography plus phlebography increases diagnostic power significantly being this combination the new gold standard for diagnostic purposes. With the data currently available, it does not seem necessary to use intravascular ultrasonography in the diagnosis and therapeutic approach of primary pelvic venous insufficiency (25,26).

REFERENCES

1. Fontcuberta García J, Juan Samsó J, Senin Fernández ME, Vila Coll R. Guía básica para el diagnóstico no invasivo de la insuficiencia venosa. Documento de consenso del Capítulo de Diagnóstico Vascular No Invasivo de la Sociedad Española de Angiología y Cirugía Vascular. Available at: https://www.cdvni.es/wp-content/uploads/2017/01/GuiaDIV.pdf
2. Fontcuberta García J, Samsó JJ, Senin Fernández ME, Vila Coll R, Escribano Ferrer JM. Actualización de la guía para el diagnóstico no invasivo de la insuficiencia venosa (I). Documento de consenso del Capítulo de Diagnóstico Vascular de la Sociedad Española de Angiología y Cirugía Vascular. Angiología 2015;67(2):125-32.
3. Fontcuberta García J, Samsó JJ, Senin Fernández ME, Vila Coll R, JM Escribano Ferrer JM. Actualización de la guía para el diagnóstico no invasivo de la insuficiencia venosa (II). Documento de consenso del Capítulo de Diagnóstico Vascular de la Sociedad Española de Angiología y Cirugía Vascular. Angiología 2015;67(3):216-24.
4. Coleridge-Smith P, Labropoulos N, Partsch H, Myers K, Nicolaides A, Cavezzi A. Duplex ultrasound investigation of the veins in chronic venous disease of the lower limbs-UIP consensus document. Part I. Basic principles. Eur J Vasc Endovasc Surg 2006;31(1):83-92.
5. Wittens C, Davies AH, Bækgaard N, Broholm R, Cavezzi A, Chastanet S, et al. Management of chronic venous disease. Clinical practice guidelines of the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg 2015;49:678-737.
6. Dong-Kyu L, Kyung-Sik A, Chang Ho K, Sung Bum C. Ultrasonography of the lower extremity veins: anatomy and basic approach. Ultrasonography 2017;36:120-30.
7. Necas M. Duplex ultrasound in the assessment of lower extremity venous insufficiency. Am J Ultrasound Med 2010;13(4):37-45.
8. Caggiati A, Bergan JJ, Gloviczki P, Jantet G, Wendell-Smith CP, Partsch H. Nomenclature of the veins of the lower limbs: An international interdisciplinary consensus statement. J Vasc Surg 2002;36:416-22.
9. Caggiati A, Bergan JJ, Gloviczki P, Eklof B, Allegra C, Partsch H. Nomenclature of the veins of the lower limb: Extensions, refinements, and clinical application. J Vasc Surg 2005;41:719-24.
10. Cavezzi A, Labropoulos N, Partsch H, Ricci S, Caggiati A, Myers K, et al. Duplex ultrasound investigation of the veins in chronic venous disease of the lower limbs-UIP consensus document. Part II. Anatomy. Eur J Vasc Endovasc Surg 2006;31: 288-99.
11. Schäberle W. Peripheral Veins. Ultrasonography in Vascular Diagnosis. Verlag-Berlín-Heidelberg-New York: Springer; 2005.
12. Oğuzkurt L. Ultrasonographic anatomy of the lower extremity superficial veins. Diagn Interv Radiol 2012;18:423-30.
13. Zygmunt JA, Sloves JM, Almeida JI. Duplex Ultrasound technical considerations for lower extremity venous disease. Endovasc Today 2020;19(3):50-9.
14. Kakkos SK, Gohel M, Baekgaard N, Bauersachs R, Bellmunt-Montoya S, Black SA, et al. European Society for Vascular Surgery (ESVS) 2021 clinical practice guidelines on the management of venous thrombosis. Eur J Vasc Endovasc Surg 2021;61(1):9-82.
15. Needleman L, Cronan JJ, Lilly MP, Merli GJ, Adhikari S, Hertzberg BS, et al. Ultrasound for lower extremity deep venous thrombosis multidisciplinary recommendations from the Society of Radiologists in Ultrasound Consensus Conference. Circulation 2018;137:1505-15.
16. Bhatt M, Braun C, Patel P, Patel P, Begum H, Wiercioch W, et al. Diagnosis of deep vein thrombosis of the lower extremity: a systematic review and meta-analysis of test accuracy. Blood Advances 2020;4(7):1250-64.

17. Meissner MH, Moneta G, Burnand K, Gloviczki P, Lohr JM, Lurie F, et al. The hemodynamics and diagnosis of venous disease. J Vasc Surg 2007;46:4s-24s.
18. Eklof B, Perrin M, Delis KT, Rutherford RB, Gloviczki P. Updated terminology of chronic venous disorders: The VEIN-TERM transatlantic interdisciplinary consensus document. J Vasc Surg 2009;49:498-501.
19. Durham JD, Machan L. Pelvic congestion syndrome. Semin Intervent Radiol 2013;30:372-80.
20. Gómez-Arbeláez D, Ansuátegui Vicente M, Comanges Yéboles A, Ibarra Sánchez G, Sánchez-Guerrero A, Villar Esnal R, González-Fajardo JA. Síndrome de congestión pélvica: revisión actualizada de la literatura. Angiología 2020;72(5):229-39.
21. Rodríguez Morata A, Reyes Ortega JP, Robles Martín ML, Gallardo Pedrajas F. Los puntos oscuros de la insuficiencia venosa pélvica. Angiología 2020;72(5):253-64.
22. Ananthan K, Onida S, Davies AH. Nutcracker syndrome: an update on current diagnostic criteria and management guidelines. Eur J Vasc Endovasc Surg 2017;53:886-94.
23. Brazeau NF, Harvey HB, Pinto EG, Deipolyi A, Hesketh RL, Oklu R. May-Thurner syndrome: diagnosis and management. Vasa 2013;42(2):96-105.
24. Zubicoa Ezpeleta S, Leal Monedero J, Elkashishi AT. Instrumental diagnosis of pelvic congestion syndrome. Phlebolymphology 2016;23(3):130-4.
25. Guerra Requena M, Rodríguez Morata A. Optimización de las pruebas de diagnóstico vascular invasivo y no invasivo en patología venosa. Tratamiento endovascular de la patología venosa. Guadalajara: AACHE Ediciones; 2018.
26. Lugli M. Intravascular ultrasound: technique, provided information and indications. Phlebolymphology 2019;26(1): 31-6.